MCubed: The Formation and Output of Incentivized Interdisciplinary Collaborations

by

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Dedication

This PhD thesis is dedicated to my grandmother, Marcella Rainey. Thanks to you and all the other women who were too stubborn to let anyone stand in your way when you decided to complete your education!

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Table of Contents

List of Tables

List of Figures

Abstract

Interdisciplinary collaboration involves many challenges. Simply finding researchers with the complementary expertise necessary to answer certain research questions can be a challenge. Once researchers find collaborators, differences in tacit disciplinary knowledge can make communication and agreement on research approaches difficult. Adding to these difficulties are the accepted norms regarding the theoretical and methodological approaches to research of the institutions surrounding various disciplines, such as university departments and publication venues. It should come as no surprise that conflicting evidence exists regarding the effect of interdisciplinary collaboration, with some studies showing benefits and others suggesting that the costs outweigh the benefits. This study uses a mixed methods approach to understand how these challenges affected the interdisciplinary projects funded by the MCubed initiative at the University of Michigan.

Many researchers who participated in MCubed found their collaborators through existing professional networks, rather than the MCubed website. While prior interactions appeared to strongly influence the researchers chosen for collaboration on MCubed projects, those prior interactions did not appear to influence output from those projects. The use of certain technical tools—specifically, shared file repositories—was positively correlated to certain types of project output. The degree of institutional financial support—both within a department and the funding available to various disciplines—played a large part in both the decision to collaborate on a project and the output from a project. Each research project can produce a wide range of outputs. The perceived value of that output is greatly influenced by the norms of each discipline, as evidenced by individual departments and larger disciplinary institutions, such as funding

agencies and publication venues. Moreover, disciplinary similarity was positively correlated to peer-reviewed project output. These findings suggest that the benefits of interdisciplinary collaboration are a matter of perception and degree.

Chapter 1

Introduction

1.1   A Large-Scale Experiment in Fostering Interdisciplinary Collaboration

In a 2011 speech, University of Michigan (U-M) President Mary Sue Coleman noted "…when we talk about applying Michigan's creativity and scholarship to the world's grand challenges, we mean imposing challenges. Big, complex problems that require the resources of a powerful, flexible, interdisciplinary research university" (Coleman, 2011). With these remarks, President Coleman committed the university to a number of initiatives to stimulate increased interdisciplinary collaboration. Most significantly, in 2012 U-M established the $15 million MCubed program, which was designed to quickly and dramatically increase the number of interdisciplinary projects on campus. The core goal of MCubed was to encourage "new groups to work together" on "bold research at the interfaces of academic fields" (MCubed, 2012; Moore, 2012). The MCubed creators wanted to fund new, interdisciplinary collaborations focusing on high-risk, high-reward projects that would otherwise struggle to receive funding through a traditional peer review process (Zurbuchen, 2012). The MCubed founders believed that combining the point of view of multiple disciplines would result in more successful and innovative projects.

Some evidence suggests that the MCubed founders might be right: the highest performing interdisciplinary collaborations can produce more publications and citations, compared to equivalent high-performing disciplinary collaborations (Figg et al., 2006). However, plenty of evidence suggests that researchers are either not aware of the benefits associated with interdisciplinary collaboration, or that these benefits are costly to achieve. For example, a

1

network analysis of research publications found that researchers with a given scientific focus tended to collaborate with other researchers with a similar focus (Velden & Lagoze, 2012). Another study found that researchers from different disciplines were less likely to work directly with each other and publish together (Cummings & Kiesler, 2008). MCubed, then, represents an opportunity to examine the composition of interdisciplinary teams, the focus of these teams, and outcomes in terms of scientific visibility.

Specifically, MCubed offers an occasion to explore a number of open questions about interdisciplinary collaboration. First, how does the discovery of interdisciplinary collaborators vary with the introduction of tools to assist discovery? Second, how does the formation of interdisciplinary collaborations relate to the availability of institutional support? Finally, does team performance vary with degree of interdisciplinarity?

1.2 Can Those Who Want to Collaborate Find Collaborators?

Once the decision to conduct research across disciplinary boundaries is made, it is often difficult to find a collaborator in a different discipline. Researchers from different disciplines are less likely to collaborate for many reasons, often because researchers are most familiar with those in their own discipline. If a researcher is interested in pursuing interdisciplinary collaboration to address a particular problem, he or she must know someone with complementary knowledge (Hara, Soloman, Kim, & Sonnenwald, 2003). This can occur through a mutual acquaintance. A collaboration between two scientists is much more likely to occur if both researchers have a third collaborator in common (Newman, 2001).

Moreover, departments in almost any university are organized along disciplinary boundaries, and most departments are located in a single building. Collaborations are more likely between researchers who work in the same hallway or building floor, because of the opportunities for informal conversations (Kraut, Egido, & Galegher, 1988). These informal conversations allow researchers to know each other on a personal level, as well as to learn where their research interests coincide (Kraut et al., 1988). Not surprisingly, most researchers collaborate with others in their own department or work group (Bozeman & Corley, 2004).

Once a researcher finds someone with complementary knowledge, that person must be open to collaboration (Hara et al., 2003). Researchers who are similar demographically, or who share certain characteristics such as similar age and education, will be more likely to collaborate

(Cummings & Kiesler, 2008; Phelps, Heidl, & Wadhwa, 2012). Furthermore, many researchers choose to work with collaborators of the same nationality (Bozeman & Corley, 2004). Personality and previous experience also affect whether researchers choose to collaborate, especially when those collaborations are interdisciplinary. Some researchers choose collaborators based on how much they enjoy working with the other person (Bozeman & Corley, 2004). Another common collaboration strategy involves a mentoring relationship, where senior researchers enjoy helping junior researchers (Bozeman & Corley, 2004). All of these strategies are most likely to take place within a single department, rather than across departments. Essentially, finding someone to collaborate with on a research project is often easier said than done.

Finding collaborators can be difficult, and personal and professional networks are often the first resource people turn to when searching for someone to fill that need (Ehrlich, Lin, & Griffiths-Fisher, 2007; Hara, Soloman, Kim, & Sonnenwald, 2003). While multiple systems have implemented social networking features for research collaboration, it has not worked outside certain areas. Originally, the systems were focused on finding an expert to solve a particular problem, or answer a specific question. The problems with this approach is that a research collaboration is often a longer term relationship, so extra information and effort is required to find someone who is knowledgeable and who has a compatible work style (Hara et al., 2003; Schleyer et al., 2008b). Later systems integrated basic expertise location into existing social networking sites or created stand-alone systems that could be described as "Facebook for scientists" (Bedrick & Sittig, 2008; Cohen, 2007; Krafft, Cappadona, Caruso, & Corson-Rikert, 2010; Schleyer et al., 2008a). These systems, which had a goal of providing researchers with the information necessary to "develop and maintain contextually embedded collaborative relationships," became known as Research Networking Systems, or RNSs (Schleyer, Butler, Song, & Spallek, 2012).

1.3   Is the Institutional Environment Supportive?

At a national level, funding for interdisciplinary research projects can be scarce. Funding agencies influence research by establishing which research problems they are willing to fund, as well as the theoretical and methodological approaches the agency acknowledges as appropriate for solving those problems (Figg et al., 2006; Funk & Owen-Smith, 2012; Knorr-Cetina, 2009).

The potential problem is that these funding mechanisms are often set up along disciplinary boundaries, which may reduce the probability of funding an interdisciplinary proposal (Figg et al., 2006; Rhoten & Pfirman, 2007). This can occur because the lack of ties to a focal disciplinary community can also undermine consensus in favor of interdisciplinary proposals within the peer-review process (Fischer, Giaccardi, Eden, Sugimoto, & Ye, 2005; Rhoten & Pfirman, 2007). While there have been calls to address these narrow biases, this is not something that changes quickly (Lane, 2009).

Complicating matters further, different disciplines have idiosyncratic and unspoken norms that may not be immediately obvious to an outsider, such as the publication of results (Sonnenwald, 2008). This can translate into a lack of natural or automatic venues for publication, because interdisciplinary research is rarely a perfect fit to existing disciplinary journals and conferences (Rhoten & Pfirman, 2007). Moreover, recognized publication venues can vary widely from one academic discipline or department to the next. Computer science departments value conferences because the speed at which technology changes requires that research results be quickly disseminated. In contrast, humanities fields tend to prefer books, where an idea can be explored in depth, and time is less of an issue. Many fields value journal articles, which can vary widely in time to publication. Often, highly regarded publication venues in one discipline are completely invalid in another. Together, these factors can lead to less recognition for interdisciplinary work—through fewer publications or through publications in the wrong venues—and lead to difficulties achieving tenure (Rhoten & Pfirman, 2007).

The organization to which an individual belongs is also critical in determining how creative and innovative an individual or group is (Amabile, Conti, Coon, Lazenby, & Herron, 1996). Interdisciplinary research is often perceived as risky, and organizational norms and attitudes toward risk shapes the behavior of members of an organization (Hargadon & Sutton, 1997). If collaboration and cooperation across disciplinary and departmental divides is encouraged, an organization's members will work to follow and live up to those norms (Sutton & Hargadon, 1996). In practice, this means organizations that want to stimulate creativity need to encourage diversity and autonomy, while providing the necessary resources (Amabile et al., 1996).

The immediate institutional environment surrounding individual collaborators impacts the success of interdisciplinary collaboration (Hara et al., 2003). How a researcher's department,

school, or college values interdisciplinary research can either enable or constrain a researcher's opportunities to stretch disciplinary boundaries (Castán Broto, Gislason, & Ehlers, 2009). Even if a university or institution supports interdisciplinary collaboration, departments within that university may not share the same view of interdisciplinary research (Castán Broto et al., 2009). The less support interdisciplinary researchers receive across the various levels of an institutional environment, the less likely it is that an interdisciplinary research project will form and succeed.

1.4 Does Interdisciplinary Collaboration Confer Important Benefits?

Social creativity is critical for complex design, which is the core of most scientific and engineering endeavors (C. R. Aragon, Poon, Monroy-Hernández, & Aragon, 2009; Farooq, Carroll, & Canoe, 2008). In the ideal collaboration, group members share ideas, receive constructive criticism, and merge the best ideas to accomplish a shared goal (Farooq et al., 2008; Larsson, 2003). This merging of individual and social creativity can become even more powerful when researchers from different fields come together to solve complex problems, creating a community of interest (Fischer, 2001). These communities of interest have the potential to generate more innovative knowledge and creative ideas (Fischer, 2001).

Some supportive studies have found that functional and educational diversity are positively related to innovation (Reiter-Palmon et al., 2011) because diverse backgrounds and training bring new tools to bear on the problem (Page, 2007). Interdisciplinary research has been defined in multiple ways. The key themes common to these definitions are the integration of concepts, theories, and methods from multiple academic disciplines to address problems that are too complex for a single discipline to solve (Repko, 2007). Ideally, each person in an interdisciplinary collaboration has the potential to improve the overall solution, because each person thinks about the problem in a different way (Hong & Page, 2004).

The problem is that there are many ways an interdisciplinary collaboration can be less than ideal. As mentioned earlier, the output from an interdisciplinary collaboration may vary significantly from discipline to discipline, and what is recognized as a contribution can vary widely as well. Beyond contribution, different disciplines have many other potential points of contention, from language to timing issues (Jackson, Ribes, Buyuktur, & Bowker, 2011; Zimmerman, 2008). Demographic diversity can also create friction (Bell, Villado, Lukasik, Belau, & Briggs, 2011). A variety of studies have found that gender and ethnic diversity can

have a small negative impact on team performance, especially when creativity and innovation are an important aspect of performance (Bell et al., 2011). Research suggests that problems with diversity are most likely to occur when teams are separated by "fault lines" (Bell et al., 2011). These fault lines occur when teams differ along two or more dimensions. In this case, dimensions refer to characteristics, such as demographics, where members of a team might differ. For example, a single female member of a team would be expected to experience fewer problems if she were one of two physicists on the team, than if she were the only social scientist on a team of doctors (Bell et al., 2011). Essentially, team diversity along multiple dimensions can interact negatively if all the differences interact to impact the same people. If these factors combine in negative ways, the potential benefits of diversity are lost (Page, 2007; Reiter-Palmon et al., 2011).

One hypothesized source of difficulty within interdisciplinary collaborations is the lack of common domain knowledge (Fischer, 2001). When collaborating researchers do not share the same base domain knowledge, communication becomes much more difficult (Fischer, 2001). This means that collaborators must educate each other about the theories and methods common in collaborators' respective fields, and this takes time to establish—and may still be incomplete or absent (Mauz, Peltola, Granjou, van Bommel, & Buijs, 2012; Pennington, 2008).

The difference in domain knowledge is also a problem when researchers in different research communities attempt to exchange data. Sharing data is challenging even within a single scientific domain, because data are almost inextricable from the context in which they were collected (Zimmerman, 2008). This exchange becomes much more difficult when researchers do not share a domain's tacit and theoretical knowledge (Faniel & Zimmerman, 2011). Another critical aspect of domain knowledge is the language, or jargon, used by researchers from a particular domain. When two researchers come from the same discipline, they essentially speak the same jargon-based language. It is not uncommon for different disciplines to have very different definitions for the same word. For example, cognitive psychology defines insight as "when a solution is computed unconsciously and later emerges into awareness suddenly" (Kounios & Beeman, 2009). In contrast, visualization researchers define insight as discoveries about data (Smuc et al., 2008). If researchers in these two disciplines are not aware of the difference in their respective definitions of insight, there is potential for confusion. Even if a common knowledge base is established, challenges must still be overcome. Every discussion

6

around a research project becomes a potential point of renewed social friction, and the greater the distance between disciplines, the greater the potential amount of friction (Edwards, Mayernik, Batcheller, Bowker, & Borgman, 2011). Even agreeing on how to answer a particular research question can lead to conflict when researchers have different views on what research methods to use (Mauz et al., 2012; Sonnenwald, 2003).

These challenges are far from insignificant, which means that the benefits of a diverse team can only be leveraged if positive social processes, such as open communication, are in action (Page, 2007; Reiter-Palmon, Ben Wigert, & de Vreede, 2011). Effective communication—either face-to-face or through technical means such as email or videoconferences—is critical for establishing the common ground necessary for an interdisciplinary collaboration (Hara et al., 2003; Ilgen, Hollenbeck, Johnson, & Jundt, 2005). Communication is especially important during the early planning stages, and when researchers are writing up the results of their projects (Kraut et al., 1988). Knowledge exchange and strategy development are particularly critical at the beginning of a project and later, when unexpected problems occur (Ilgen et al., 2005; Sutton & Hargadon, 1996).

Group dynamics and the social context of a collaboration are critical to the process of creativity and innovation (Hargadon & Sutton, 1997; Hennessey & Amabile, 2010). An important aspect of the social context within a collaboration is the amount of trust between group members, and an openness to entertaining new ideas (Hemlin, 2009). Increased communication is associated with increased trust, partly because maintaining trust and keeping goals aligned require regular communication (Cummings & Kiesler, 2007; Olson & Luo, 2007). Many researchers describe collaboration as a "marriage," with the same need for trust, communication, and mutual effort (Hara et al., 2003). As described above, differences of opinion regarding methodological and theoretical approaches are likely (Azmitia & Crowley, 2001). Mutual trust and openness to new ideas is critical if a team is to successfully resolve these differences of opinion.

The high level of trust that makes collaboration more likely to be successful often takes time to develop. Recent research suggests that "extremely strong super ties," characterized by "trust, conviction, and commitment," are positively correlated with increased publication and citation rates (Petersen, 2015). These extremely strong ties were defined as collaborations that produced a high number of publications over an extended time period, indicating that prior

interactions are essential to developing the trust necessary to perform effective interdisciplinary research. This would certainly explain findings that indicate researchers tend to collaborate with those they are already working with (Bozeman & Corley, 2004).

With these challenges facing interdisciplinary collaborations, research suggests that similarity is more important. Some research finds that collaborators who share certain characteristics, such as age and education, are more likely to produce innovative results (Cummings & Kiesler, 2008; Phelps et al., 2012). This homophily, or similarity, means that collaborators have more common ground, which makes communicating easier (Cummings & Kiesler, 2008). While there are certainly solid arguments for the benefits of interdisciplinary collaboration, a multitude of problems can severely undermine the success of those projects.

1.5   Conclusion

This chapter described a set of relevant and important open questions concerning interdisciplinary collaboration. I will address these questions through data collected on the MCubed effort (described in detail in Chapter 2). The sections that follow describe my data gathering and analysis strategies and the organization of the thesis around the set of open questions presented in this chapter.

1.5.1   Chapter 2

In Chapter 2, I will address the first two questions raised in section 1.1: 1) How does the discovery of interdisciplinary collaborators vary with the introduction of tools to assist discovery?; and 2) How does the formation of interdisciplinary collaborations relate to the availability of institutional support? In response to the first question I will examine the impact of the MCubed website, designed to serve many of the functions found in an RNS. In particular, using analysis of the MCubed website logs, I will explore whether the patterns of activity observed were consistent with the goal of increasing the ease and likelihood of finding interdisciplinary collaborators. This portion of Chapter 2 investigates whether "new groups" took advantage of MCubed, as the MCubed administrative team hoped (MCubed, 2012; Moore, 2012). In response to the second question I will examine variation in unit-level participation in MCubed related to formation of interdisciplinary collaborations. Specifically, I will explore the network of resulting collaborations as a function of the unit-level policies that governed allocation of support to individual investigators who wished to start or join an MCubed

collaboration. This portion of Chapter 2 investigates whether collaborations that take place "at the interfaces of academic fields" encounter extra difficulties that may keep the collaboration from forming (MCubed, 2012; Moore, 2012).

1.5.2   Chapter 3

Chapter 3 does not directly address any of the open questions described earlier, however, it lays the groundwork that will allow me to explore the third question: Does team performance vary with degree of interdisciplinarity? A key challenge to addressing this question is selection of an appropriate dependent variable. Historically, the literature has focused on peer-reviewed publications, such as journal articles, as a definitive measure of output. A disadvantage of this approach, particularly in my case, is the long lag time that can occur between inception of a project and final realization in the form of a published result. As a pragmatic matter, then, I needed to capture production of meaningful outputs along the path toward a published result – since the timeframe of my study suggested a truncated distribution of publications (i.e., many are likely to occur outside the interval of my investigation). My solution came from analysis of CVs across the MCubed participants to produce stable categories of intermediate outputs. For example, in many fields there is a progression from non-reviewed content (e.g., a brown bag presentation), to lightly reviewed content (e.g., a poster), to rigorously reviewed content (e.g., an article in a top journal). I characterize this progression in terms of a "scholarly arc" and propose that milestones along this arc can be used as near-term measures of performance among MCubed teams.

1.5.3   Chapter 4

Chapter 4 is an examination of how team performance varies with degree of interdisciplinarity. As described above, the dependent variable for these analyses will be the stages along the scholarly arc (i.e., the influence of interdisciplinary team composition on production of non-reviewed, lightly reviewed, and rigorously reviewed outputs). The independent variables will span a set of institutional factors (e.g., amount of unit-level support), team factors (e.g., disciplinary diversity, prior history of collaboration, composition by membership group), and process factors (e.g., use of the MCubed website, time to formation for a collaboration, use of collaboration tools). The goal will be to answer questions raised by the stated goals of the MCubed program – e.g., that new and diverse collaborations outperform old

and similar collaborations – and more broadly to extrapolate from the specific MCubed setting to the setting of interdisciplinary collaboration in general.

1.5.4   Chapter 5

In Chapter 5, I explore the larger implications of Chapters 2, 3, and 4. First, I focus on how units differed in their approach to MCubed and how this affected project formation. Second, I consider the results of using all research outputs when attempting to answer the questions posed here, and what may be adjusted in future studies. Finally, I discuss how various types of diversity affect project outcomes and what that implies for interdisciplinary team composition. This chapter will also address limitations and weaknesses of my study and approach.

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13

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Chapter 2

MCubed: Finding Collaborators and Forming Collaborations

2.1 Introduction

This chapter describes two studies. The first study addresses whether the discovery of potential interdisciplinary collaborators varies with the introduction of tools to assist discovery (e.g., RNSs). Specifically, the MCubed team designed the MCubed website to function as an "academic matchmaker." Despite this goal, evidence suggests that most researchers found their MCubed collaborators without using the website, and I explore reasons why it wasn't more useful. The second study addresses whether the formation of interdisciplinary collaborations varied with the level of institutional support. Specifically, the MCubed team wanted teams to form and propose projects independent of funding and review constraints. Despite this goal, evidence suggests that the creation of teams was strongly conditioned on unit-level policies, such that many more "cubes" were formed and joined by faculty in units with generous support for faculty participation – and that some teams and projects were precluded by the lack of unit support.

In 2012, the University of Michigan established the MCubed program, which provided $15 million in U-M funds to jumpstart interdisciplinary faculty projects. Each eligible faculty member was given a token worth $20,000 byhis or her home unit. Individual units defined who was eligible for the tokens. Of the $20,000, one-third came from the Provost's office. The remaining two-thirds was split between individual researchers and their home units. Units varied in the number of tokens distributed, the number of tokens they would ultimately fund, and the amount the unit would contribute to each token's value. To receive MCubed funding, a project

would need three collaborators, or token holders, from at least two different university schools or colleges.

2.2   Study 1: Mcubed as a Research Networking System

Finding collaborators can be difficult, and personal and professional networks are often the first resource people turn to when searching for someone to fill that need (Ehrlich, Lin, & Griffiths-Fisher, 2007; Hara, Soloman, Kim, & Sonnenwald, 2003). Unfortunately, personal networks are not effective for finding collaborators in all circumstances. For instance, a researcher who is just starting her career will probably have a much smaller professional network than a researcher with decades of experience. A variety of systems have been developed to address this problem.

While multiple systems have implemented social networking features for research collaboration, it has not worked outside certain areas. Originally, the systems were focused on finding an expert to solve a particular problem, or answer a specific question. The functionality of these systems centered on providing information about an individual's knowledge of a given area. While this worked well for answering a specific question, it fell short when searching for a collaborator.

A research collaboration is often a longer term relationship, so extra information and effort is required to find someone who is knowledgeable and who has a compatible work style (Hara et al., 2003; Schleyer et al., 2008b). Some systems that sought to address these challenges integrated basic expertise location into existing social networking sites (Bedrick & Sittig, 2008). Others created stand-alone systems that could be described as "Facebook for scientists" (Cohen, 2007; Krafft, Cappadona, Caruso, & Corson-Rikert, 2010; Schleyer et al., 2008a). The NIH and other national funding agencies started to pay attention, and announced a request for applications to develop cyber-infrastructure to "encourage interdisciplinary collaboration and scientific exchange" as part of the 2009 Recovery Act (National Center for Research Resources, National Institutes of Health, Health & Services, 2009).

Soon after this, the term Research Networking System, or RNS, became the default term for these types of systems. RNSs have been defined as "systems which support individual researcher's efforts to form and maintain optimal collaborative relationships for conducting productive research within a specific context" (Schleyer, Butler, Song, & Spallek, 2012). With

this definition, it can be argued that the goal of an RNS is to provide researchers with the information necessary to "develop and maintain contextually embedded collaborative relationships" (Schleyer et al., 2012).

Unfortunately, there is not much research on RNSs (Schleyer et al., 2012). One previous study has emphasized how visitors used the site, rather than who those visitors were (Kahlon et al., 2014). The study authors relied on Google Analytics, which can only offer general answers about who is visiting a website (Kahlon et al., 2014). Other studies have better answers about who is using the website. For example, a study of an RNS at Columbia University found that scientific administrators, faculty members, and research scientists all differed in how they used the site, and time spent on the RNS (Boland, Trembowelski, Bakken, & Weng, 2012). A paper on the VIVO system developed at Cornell University only provided anecdotal evidence of the system's effectiveness in helping faculty at Cornell to find collaborators (Krafft et al., 2010).

Neither of these studies offered any insight into how institutional RNSs actually facilitated research collaborations. While understanding general usage patterns is helpful, many questions are left unanswered. For example, how do visitors find potential collaborators and how long does it take for visitors to find someone who meets their criteria? Who is using RNSs?

This leads to two research questions. First, do RNSs help researchers find collaborators, and if so, how? Second, who is using RNSs to find collaborators?

2.2.1 Methods

Previous studies of RNSs focused on very high level analyses of website use (Boland et al., 2012; Kahlon et al., 2014). These studies used Google Analytics to inspect the number of steps to complete each task, the relative use of the RNS by various groups, and the general types of queries people performed, breaking the analyses down by various groups (Boland et al., 2012; Kahlon et al., 2014). In addition, the analyses included the general types of queries entered into the system, such as searching by faculty name or by topic (Boland et al., 2012; Kahlon et al., 2014). While this is useful information, why people are looking for collaborators or mentors through the RNS is not addressed. Moreover, how visitors found potential collaborators is not resolved.

Other RNS studies have used a mixed method approach. For example, IBM researchers used a combination of surveys and highly aggregated log data to evaluate satisfaction with an

expertise location system (Ehrlich et al., 2007). This combination is fairly common, and has been used in later evaluations of RNSs and other collaborative platforms, including studies of Wikipedia and scientific collaboration patterns (Geiger & Ribes, 2011; Kahlon et al., 2014; Velden & Lagoze, 2013).

A more detailed analysis than provided by Google Analytics is required to answer the types of questions presented earlier. Trace ethnography, an alternative method proposed by Geiger & Ribes, can help to answer some of these questions (Geiger & Ribes, 2011). Essentially, trace ethnography entails decoding automatically-generated traces, such as website log entries, to understand individual actions within a larger social context (Geiger & Ribes, 2011). This detailed study of traces is combined with a deep understanding of the tools and procedures that generate those traces (Geiger & Ribes, 2010).

2.2.1.1 Participants

The population for this study was the MCubed token holders, with extra emphasis on those who were actively creating projects and committing their tokens to projects on the MCubed website.

2.2.1.2 Data sources

Token holders were required to propose and formally agree to collaborate on a project though the MCubed website, which gave me a unique view into the process of finding interdisciplinary collaborators. While offline communication between collaborators was unavailable, certain inferences could be made based on researcher actions on the website. In addition, every eligible researcher had a personal profile on the MCubed website. This allowed for a better understanding of which researchers were actively using the website.

Data from the MCubed website fell into two general categories: MCubed website log files, and scrapes of the token holder and project web pages. First, I studied the MCubed website log files, which recorded every action a visitor took on the MCubed website. The website log files contained the type of information normally found in log files: a user identifier, a timestamp, the current page, the referring page, and a description of the type of action the user was taking on the website. Third, I saved the full html code for pages that listed MCubed token holders by unit, and all projects created on the MCubed website.

2.2.1.3 Procedure: Trace ethnography

I began observing the MCubed website in September 2012, about a month before it was first opened to token holders in October 2012. This gave me the opportunity to interact with the website and get to know the tools that would be available to the token holders as the website developers were finalizing the testing of those tools. At the same time, I had complete access to the website log files. To understand individual items within the MCubed website log files, I performed a variety of actions on the site before it was opened to token holders. During this time I fully explored the functionality offered by the MCubed website. I also observed the web logs created by the website developers and MCubed administrators as they tested the system prior to launch. Once the website was opened to token holders, I regularly studied the website logs. This allowed me to see the coordinated actions of researchers looking for collaborators on the MCubed website. I also read the descriptions of all new and updated projects on the website, as well as the token holder profiles of any project collaborators.

These ethnographic observations often provided key insights that I later verified through a more quantitative analysis of the MCubed website log files. The log files and data sets derived from the log files were stored in an SQL database for later retrieval and processing. A variety of scripting languages (PHP, Python, D3 Javascript visualization library) and the IBM SPSS statistical package were used for additional data processing and analysis.

2.2.2   Results: Realities of how the MCubed website was used

Helping researchers find collaborators was one of the primary goals for the MCubed website. While there were certainly instances where this occurred, it did not happen in the majority of cases. The data from the website log files suggest that many teams made their collaborative arrangements before logging into the website. The website was simply used for the administrative act of committing tokens to a project.

2.2.2.1 The MCubed administrative team's goals for the MCubed website

The MCubed team felt the MCubed website was a critical part of what would make MCubed work. All projects competing for MCubed funds had to be posted on the MCubed website, and all collaborators had to indicate their agreement to work on a given project through the website. During information sessions, the MCubed administrative team described the MCubed website as a combination of "Kickstarter and Facebook" that would act as an "academic

matchmaker." They wanted eligible researchers to find collaborators through the website. They envisioned that the website would be used by researchers to either create a project and start looking on the site for people who could be a good fit for the project, or that people would look for interesting projects on the site.

The MCubed team wanted the website to be more than a place for people to officially commit their token to a project in order to get funding. They also wanted the website to be a place where researchers exchanged ideas and discussed the projects they were working on. The hope was that project collaborators would post updates on the project's progress, and that others would comment on those updates, offering ideas and knowledge, both before and after a project received funding. When one researcher praised another research's project and offered to discuss the project—despite having already committed his MCubed funds to another project—the comments were highlighted in the MCubed blog. This was exactly the type of interaction the MCubed team had hoped for. In some ways, the MCubed team may have viewed the funding as a forcing mechanism to encourage university researchers across disciplinary boundaries to discuss and collaborate on projects.

2.2.2.2   General use of the MCubed website

In August 2013, at the time MCubed completed distributing funds for its pilot phase, there were just over 1.5 million visitor actions logged on the site. These actions included everything from viewing the MCubed home page to creating projects and requesting funding for those projects (once the projects had the required number of collaborators).

Only authorized users who logged into the website could see all proposed projects and profile pages of other eligible researchers. While every eligible researcher had the option to peruse every part of the MCubed website, only a portion of them (856 out of 2155) actually did so (see Table 2-1). Another 176 only visited the website briefly, and did not attempt to create a project or collaborate on someone else's project.

Level of Activity	Funded Token Holders (%)	Unfunded Token Holders (%)	Category Total (%)
None	0.0	57.5	39.7 (856)
Light (1-25 actions)	14.3	11.7	12.5 (269)

Some **(26-100 actions)**	26.4	10.8	15.6 (337)
Moderate **(101-500 actions)**	39.5	13.9	21.8 (470)
Heavy **(>500 actions)**	19.8	6.0	10.3 (222)
Total	100.0 (666)	100.0 (1488)	100.0 (2154)

Table 0-1: Overall website activity for token holders

Additionally, the extent to which token holders typically visited the MCubed website changed after committing their token to a project that was later funded (see Table 2-2). For example, while about 94% of funded token holders used the MCubed website more than occasionally prior to committing their token to a project, less than 65% of funded token holders used the MCubed website at that level after committing their token to a project. Heavy use of the MCubed website only stayed relatively consistent before and after committing a token, and even that level dropped by about 5%.

Level of Activity	**Before Committing Token (%)**	**After Committing Token (%)**
None	0.0	1.4
Light **(1-25 actions)**	5.9	35.3
Some **(26-100 actions)**	35.7	18.9
Moderate **(101-500 actions)**	19.7	11.0
Heavy **(>500 actions)**	38.7	33.5
Total	100.0 (666)	100.0 (1488)

Table 0-2: Level of website activity for token holders before and after committing to a project that was later funded

Table 2-3 tells a more complete story, by comparing how an individual's use of the MCubed website changed before and after agreeing to collaborate on a project that was funded later. Most users who were light to moderate website users before agreeing to collaborate on a project continued to be light to moderate website users after agreeing to collaborate on a project. Most of

the eligible faculty who were heavy users of the MCubed website continued to heavily use the MCubed website at similar levels after agreeing to collaborate on a project. Overall, most people either used the MCubed website just to perform the administrative tasks necessary to get their MCubed funds, or they explored the site extensively, both before and after agreeing to collaborate on a project.

Level of Activity (% of funded users)	AFTER			
	Light (1-25)	Some (26-100)	Moderate (101-500)	Heavy (> 500)
B E F O R E **Light (1-25)**	5.1	0.6	0.0	0.2
Some (26-100)	17.7	7.8	4.1	6.2
Moderate (101-500)	6.6	3.6	3.0	6.5
Heavy (> 500)	7.2	6.9	3.9	20.7

Table 0-3: Activity of funded researchers on MCubed website before and after committing a token to a project. (N=666)

2.2.2.3 Project creation and funding

Figure 2-1 shows that most projects had all three collaborators in place within a few days of the creation of that project. Fifty-eight percent of the projects created in the first funding phase had all their collaborators in place within a week. Over half of those were filled within a day. It is likely that the other 24% had to restructure their collaborative arrangements because the departments of the original collaborators ran out of funding.

% of projects to fill with 3 tokens in the given time frame**

first_cubes
second_cubes
third_cubes

	1day	2days	3days	4days	5days	6days	1week	2weeks	3weeks	4weeks	5weeks	6weeks	7weeks	8weeks	>8weeks
first_cubes	34%	8%	4%	6%	4%	0%	2%	10%	8%	4%	12%	4%	0%	0%	4%
second_cubes	31%	14%	9%	7%	3%	4%	2%	9%	4%	4%	9%	3%	0%	1%	2%
third_cubes	28%	11%	6%	6%	2%	4%	6%	2%	2%	7%	2%	2%	2%	0%	22%
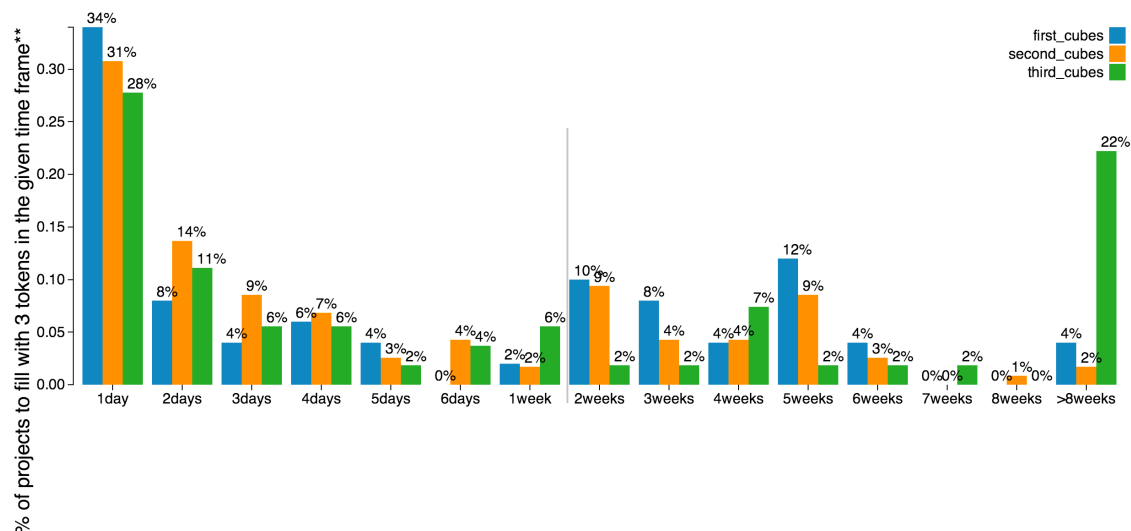
Figure 0-1: Elapsed time between project creation and last collaborator committing his or her tokens for all MCubed projects with at least three collaborators

This trend was even more pronounced for projects created during the second funding phase of MCubed. In this phase, 70% of the created projects were filled with the requisite three eligible tokens within a week of project creation. Just under half of those projects were filled within a day of project creation. Similar to the first funding phase, 26% of the projects took between a week and a month to gather the requisite number of collaborators. This is not surprising, because many units ran out of available funding in the second phase. Multiple projects had to restructure their collaborative arrangements after several departments ran out of available funding.

The third funding phase looks superficially similar to the first two funding phases in that 63% of the projects created during this time were filled within a week, and almost half of those were filled within a single day. Where the third phase differs is in the number of projects that took over two months to fill. Where only a few projects took over two months to fill in the first two funding phases (4% and 2% respectively) 22% of the projects created during the third phase took over two months to fill with collaborators.

This probably occurred because there was less demand for MCubed funds. In the first phase especially, the number of projects MCubed was willing to fund was far smaller than the number of projects requesting funds. Initially, there was also more uncertainty regarding how and when those funds would be distributed, as detailed above. In the last week of the first

funding phase—when project creators could indicate their interest in competing for the relatively small number of funding slots available—the number of projects created and filled jumped dramatically. In the second phase, the competition for fundable projects was also stiff, although for different reasons. There were more funding slots available than projects requesting funding, so in theory the competition should have been less. Unfortunately, certain units had more funding requests than available funds. In most cases, the units that would run out of funds were rather small, such as Art or Music. The biggest reason for projects not receiving funds in the second funding phase was because Medicine, the dominant unit in the MCubed program, would also run out of funds allocated to MCubed. Therefore, any project that included a Medicine collaborator in the second funding phase had a chance of not getting funded.

In contrast, the selection process for the third funding phase was quite different. Instead of randomly selecting projects to fund from a list of projects requesting funds, the process was first-come, first-served. The MCubed team made this decision because in the second phase there were more projects requesting funds than available funding slots. While there was relatively intense activity in the first few hours of the opening of the third funding phase, this activity declined quite quickly. The number of funding requests, previously measured in number of requests per day, became measured in number of requests per month. This gave anyone interested in getting MCubed funds the luxury of taking their time to find collaborators, instead of furiously making arrangements over the course of a few days.

2.2.2.4   Finding People and Projects on the MCubed website

The number of searches for other people on the MCubed website varied widely, with a long tail at the bottom end. The average number of other people someone searched for was just over five searches (5.3), with a maximum of 60. Searches could be broken down into two main categories: keyword searches and name searches. There were multiple reasons people searched for other people. Some were actively searching for collaborators. Twenty-one percent of all token holder searches were for people they eventually collaborated with on a project. A small portion of token holders (8%) searched for themselves. Both project creators and project collaborators were equally likely to search for themselves (4%). The number of searches for people who eventually collaborated on a funded project was also very similar for project creators (11%) and project collaborators (10%). Table 2-4 shows search patterns broken down by project

creators, and those who committed their tokens to someone else's project. The greater number of project creator token holder searches is even more dominant considering that there are two funded project collaborators for every one funded project creator.

Type of Token Holder Search	Searches by Project Creators	Searches by Project Collaborators	Searches by All Funded Token Holders
Name Search	41%	32%	72%
Keyword Search	15%	12%	28%
Total Searches*	56%	44%	100%

Table 0-4: Searches for people on the MCubed website by funded token holders. (N=1842)

The number of searches for projects on the MCubed website did not vary as much as the token holder searches, but there was still a long tail at the bottom end. The average number of persons someone searched for was almost three searches (2.8), with a maximum of 39. As with the token holder searches, project searches could be broken down into two main categories: keyword searches and name searches. Not surprisingly, keyword searches were much more prevalent in project searches than in token holder searches, with 64% of project searches being keyword searches. People might search for a project for multiple reasons. Many of the keyword search terms used were keywords related to the project a token holder would commit their token to, with 18% of project keyword searches by project creators and 22% of project keyword searches by project collaborators. Sixteen percent of all project searches were for those a token holder eventually collaborated with on a project. A small portion of token holder searches (6%) were people searching for themselves. Project creators were slightly more likely to search for their own name (4%) than project collaborators (2%). In contrast to token holder searches, the number of searches for eventual project collaborators on a funded project was very different for project creators (3%) and project collaborators (13%).

Type of Project Search	Searches by Project Creators	Searches by Project Collaborators	Searches by All Funded Token Holders
Name Search	15%	21%	36%
Keyword Search	28%	36%	64%

Total Searches*	43%	57%	100%

Table 0-5: Searches for projects on the MCubed website by funded token holders. (N = 1842)

2.2.2.5   Examples of how the website was used

As Table 2-5 suggests, many token holders who received funding through the MCubed website either 1) only used the website to perform the administrative tasks necessary to request and receive funding (17.7%) or 2) made extensive use of the website both before and after performing the administrative tasks required to request and receive funding (20.7%). Figure 2-1 illustrates that between one third and one half of the projects on the MCubed website were created and met the funding requirements in just one or two days. The next section describes the timelines for website users and projects that illustrate these trends.

The projects selected for this section were chosen using two criteria. First, the projects fitted one of the trends pictured in Figure 2-1; specifically, that the collaborations either formed quickly or took an extended amount of time to form. Second, within the projects that met these criteria, at least one of the collaborators exhibited the more dominant website use patterns depicted in Table 2-5. Of the projects and collaborators that met these criteria, the example project was chosen randomly. As a note, some details, including names, have been changed.

2.2.2.5.1 Light website use and quick project formation, early funding

In the project selected for this illustration, two collaborators had primary appointments from a multi-disciplinary school, and the third was from a school that focused on applied science and engineering. The two faculty members from the multi-disciplinary school had secondary appointments at the same school as the third collaborator. Two collaborators were well established in their respective specializations, and the third was still in the early stage of his career. The senior collaborator with a joint appointment in the two departments had two offices, each of which was in the same building as offices of the other two collaborators. A caveat is that enough distance separated those two buildings that walking from one building to the other was not practical.

One of the collaborators, Susan, was moderately active on the website from the very beginning. She initially spent a few minutes exploring the MCubed website on the day it opened

for use. About a month later, Susan logged into the website again, and spent about five minutes searching for projects that were in her computer science area.

About a month later David, the project creator, logged into the website for the first time. David spent a few minutes browsing the help pages, and created a new project. Then he made a series of updates to his personal profile on the website. Once that was complete, David invited two people, Susan and Guarav, to collaborate on the project with him. He made a few changes to the project, and left the MCubed website. About twenty minutes after David invited Susan to collaborate, she viewed the project, which was directly related to the searches she had performed a few days before.

Two days later, Guarav logged onto the MCubed website for the first time. He quickly glanced through the website help, and then spent a few minutes reading about David's project. Guarev made a series of changes to his personal profile, and accepted David's invitation to collaborate.

About thirty minutes after Guarav logged off the MCubed website, Susan logged on and searched for David on the MCubed website. After she took a quick look at David's project, Susan made a series of changes to her profile, and accepted David's invitation to collaborate. David's project had now met the requirements to request MCubed funding.

About half an hour later, David logged back onto the MCubed website and made a series of changes to the project. The next day, he formally requested participation in the first semi-random lottery funding distribution phase, described above. With 127 projects competing for 50 funding slots, it probably came as no surprise when David's project was not selected in the first phase of funding distribution.

On the day the MCubed administrative team announced that project creators could again request funds, all three collaborators logged on, Susan and Guarav for the last time. That evening, David logged onto the website to again formally request funds. Guarav logged onto the website very soon after, perhaps to confirm that the request appeared correctly on the website. Two weeks later, the project was selected to receive MCubed funding. David briefly logged onto the MCubed website once more, almost six months later. During this visit, he spent some time browsing the help pages.

2.2.2.5.2 Heavy website use and slow project formation, late funding

In this illustration, all collaborators were in the middle of their respective careers. All three were from different departments, two of which were health related and the third emphasized social interactions. While one of the collaborators had a secondary appointment in the same college as another collaborator, none of the collaborators had offices in the same building. Two of the collaborators had offices in buildings that were within walking distance of each other.

Matt, one of the collaborators, first spent a few minutes searching for researchers from a specific unit on the MCubed website on the day it opened for use. The next time he logged on was on the first day researchers could request funding for their projects in the second funding phase. Daniel took a quick look at a project that was created by a departmental colleague, and logged off.

The next time Matt visited the MCubed website was in mid-February, prior to the announcement of the third funding phase. He spent about ten minutes searching for other researchers. First, Matt searched by keyword, presumably in an area of interest to him. After about five searches, Matt began sprinkling in specific names of researchers. About ten minutes later, Matt paged through all the projects created on the MCubed website, first looking at all of the projects, and then limiting his browsing to just projects that could theoretically be funded, because they had three tokens committed to the project. He looked at a few projects in more detail, but quickly went back to browsing. All this took less than ten minutes.

Sarah, another collaborator, first visited the MCubed website in mid-January, but this visit only lasted a few minutes. The day before the third funding phase was announced in late February, Sarah logged into the MCubed website for a second time. During this visit she searched for users by name, one of which was a researcher she later decided to collaborate with.

About a month later the third collaborator, Nina, visited the MCubed website for the first time. Initially, she spent about five minutes browsing through other researchers, later limiting her search to specific departments. At this point, Nina updated her own profile on the MCubed website. A few hours later, Nina returned to the MCubed website. Once again, she spent a few minutes browsing through researchers from specific units. This time, she took a closer look at the profiles of various researchers, one of whom she eventually ended up collaborating with.

28

Nina created a project about ten minutes later and continued to search for other researchers. First, Nina searched for a particular keyword, and spent a few minutes looking more closely at some of the researchers from this search. Nina spent the next twenty minutes browsing through all the researchers on the MCubed website, occasionally pausing to take a closer look at someone's profile. A few days later, Nina repeated this browsing pattern, but looked at different researcher profiles.

The next day, Nina took a few minutes to glance through all the projects on the MCubed website. She updated the project she had created, and invited Sarah to collaborate. Nina logged into the MCubed website a few days later, and spent a few minutes browsing through all the projects. She made a quick change to her project and invited Matt to collaborate. At that point, Nina browsed projects from a specific department and logged off the website.

Matt logged onto the MCubed website the day after that and searched for Nina's project. After Matt reviewed his own profile he spent a few minutes searching for users, viewing one in particular. About an hour later Matt repeated this pattern, looking at other researchers. He spent about five minutes browsing projects and looking at a few projects in more detail. None of these were Nina's project.

A day later, Sarah logged onto the MCubed website for the first time in two months. She spent a few minutes viewing Nina's project, and left a comment about the project. Sarah searched for a particular researcher by name and then for researchers from a specific department.

The day after Sarah left a comment on Nina's project, Nina logged back into the MCubed website, browsing projects from specific departments. Nina took about five minutes to review her own project, and began searching for a particular researcher before returning to review her own project once again. After paging through all the projects on the website, Nina canceled her invitation to Sarah and left the website.

Nina logged back onto the MCubed website a few days later and continued to search for other researchers, taking a closer look at a few researchers' profiles. Nina repeated this again a little less than a week later. One of the researchers she looked at this time was Matt.

A week later, Matt logged back onto the MCubed website to search for specific researchers. About half an hour later, Nina logged onto the website. After reviewing her own project she re-invited Sarah to collaborate on the project. Nina then canceled Matt's invitation

and re-invited him to collaborate as well. Thirty minutes later, Matt made a few quick changes to his profile, and agreed to collaborate on Nina's project.

The next day, Sarah logged into the MCubed website and reviewed Nina's project. After that, Sarah made a few changes to her own MCubed profile. Once that was complete, Sarah formally agreed to collaborate on Nina's project. A few hours later, Nina made a few changes to her project. Once those were complete, Nina formally requested funding for the project.

Over the next month, both Nina and Matt spent a little more time browsing the MCubed website. Nina paged through the projects on the site, and looked at a colleague and the colleague's project. Matt visited the MCubed website intermittently over the course of the next few months. Each of those visits lasted only a few minutes. During one of these visits, Matt viewed the project he was collaborating on with Nina and Sarah. On a later visit, he viewed a colleague's profile.

2.2.3   Discussion: The MCubed website as an RNS

While there were certainly instances where the projects funded through MCubed met the goals of completely new, interdisciplinary collaborations, this did not happen in many cases. Figure 5 suggests that many teams made their collaborative arrangements before logging into the website. The website was simply used for the administrative act of committing their token to the project.

Individual website use varied, with most either using the site only to perform the actions necessary to receive funding, or exploring the site extensively. Some of this could be attributed to how the MCubed website functioned as an RNS, which we will discuss further in the next section. The time for projects to form also showed a bimodal distribution, as shown in Figure 5, with about a third of collaborations officially forming within a few days. Some of the reasons for this can be inferred from information available through the MCubed website and the website log files, which I will discuss in this section.

The goal of any RNS is to help people find and evaluate potential collaborators. Recent research on a few existing RNSs has led to a number of recommendations (Schleyer et al., 2012; Schleyer et al., 2008b). These recommendations focus on helping researchers to find collaborators on the RNS, and profiles to help researchers assess the personal compatibility of potential collaborators (Schleyer et al., 2012; Schleyer et al., 2008b). In this section, I will

discuss how the MCubed website did or did not meet those requirements. Additionally, I will discuss how those recommendations apply to an RNS with extra incentives for use.

2.2.3.1 Finding collaborators

Finding collaborators can be difficult, and that challenge becomes even more difficult when researchers are unfamiliar with the disciplinary terminology of potential collaborators (Schleyer et al., 2008b). This means that an RNS should provide guidance when translating domain-based terminology to other domains (Schleyer et al., 2012). While the MCubed website did allow website users to search projects and token holders, the search functionality was rather basic. Search results were based on whether a search term or phrase appeared in a project description and keywords, or in a token holder's profile. The question is to what degree complex search functionality is necessary.

Most of the keyword searches performed on the MCubed website fell into three categories. The first category was relatively general search terms such as "battery" or "prostate." In these cases, it could be argued that the searcher wanted to cast a relatively wide net. The other type of search was for very specific keywords such as "nano-theranostic" or "atrial septal defect." In these cases, the person searching knew exactly what they were looking for, and query expansion or synonym identification would have returned more results than the searcher wanted. The third type of search query is the type where synonym identification would have been useful. For example, one person searched for "heart," while others searched for "aortic" and "vascular." Columbia University implemented an RNS with search functionality that addressed these issues by performing name disambiguation, query expansion, and synonym identification (Boland et al., 2012).

In each of the categories just described, the searchers most likely had different goals. In the case of users querying a general keyword, query expansion would be appropriate. Synonym identification would be useful in the third category, where search terms are the words a layperson would recognize and use. In the second case, where the keywords are quite specific, the search function should simply return results matching those keywords.

In an ideal world, the search functionality of any RNS would be able to differentiate between different types of searches and give the searcher relevant results. However, varying the search algorithm based on the type of keyword entered could be difficult to do automatically. In

31

this case, a simpler solution would be to give the user the option to modify the search algorithm used, either before a search or to refine an existing search.

2.2.3.2   Researcher profiles

Researcher profiles are a critical aspect of an RNS. When someone is deciding if they want to contact a potential collaborator, they are inferring that person's skills, expertise, and personality based on the information in an online profile (Marlow, Dabbish, & Herbsleb, 2013). To allow this inference of compatibility, researcher profiles should be detailed and up to date, because a researcher's interests tend to evolve over time (Bedrick & Sittig, 2008; Boland et al., 2012; Schleyer et al., 2012). Because maintaining a detailed and updated profile can be time consuming, the benefits of having a complete and current profile should outweigh the costs of maintaining that profile (Bedrick & Sittig, 2008; Boland et al., 2012; Schleyer et al., 2012; Schleyer et al., 2008a). For example, the VIVO system developed by Cornell University automatically integrates data from a variety of sources, including human resources, grants, and publications, to populate researcher profiles (Krafft et al., 2010).

On the MCubed website, the detail included in profiles varied widely. Initially, the profiles were populated from information provided by departments. In some departments, a basic profile was filled out, including recent publications and a brief summary of a researcher's interests. In other schools and colleges, no information beyond name and title were included in the profile. For those that were provided by the schools and colleges, the profiles were likely reasonably up to date at the time they were created in late 2012. Whether those profiles were still up to date in mid 2014, when MCubed funded the last projects, was entirely up to the individual researcher. Researchers on the MCubed website had the option to edit their profiles at any time. By the time MCubed was finished distributing funds, 888 out of 2150 users (41%) had opted to make changes to their personal profiles.

The perceived benefits of maintaining personal profiles on the MCubed website varied from one researcher to the next. For established researchers with plenty of grant money, or those without enough money to participate, the money from the Provost and departments was not necessarily enough benefit to warrant the cost of spending extra time to maintain a profile on the MCubed website. For others, the benefit of the extra money was more than enough to outweigh the time cost of maintaining a detailed profile.

In the projects where I delved deeper into the weblogs, all the researchers edited their profiles either before or after agreeing to collaborate on a project. All projects and collaborators who received funding through MCubed would be posted on a public version of the website. This meant that the researcher's name would be publicly associated with active participation in a pilot project that was getting quite a bit of attention within the University of Michigan community. Quite possibly, this was enough incentive to ensure an accurate personal profile.

This implies that communal attention can be enough incentive for some people to maintain detailed and up-to-date profiles. For RNSs in general, this implies a necessary critical mass of more than just users, but also communal attention toward the content on an RNS. This means that people developing new RNSs should think about keeping the RNS in the mind of the community the RNS is designed to support. In the case of MCubed, the series of funding phases and symposiums that highlighted funded projects served this purpose. The key is to leverage this communal attention early, so researchers looking for collaborators have more information when deciding whom to contact.

An additional challenge is that an RNS must balance the offering of comprehensive information about a potential collaborator's interests and expertise, against an individual's desire to control how they are portrayed and who can view them (Schleyer et al., 2012). In practice, this often means that researchers are able to control the visibility of their profiles (Cohen, 2007; Schleyer et al., 2012).

Profile visibility was not left up to the researchers who were eligible to participate in MCubed. The profile of every researcher who was eligible to participate in MCubed was visible to all other eligible researchers or department administrators. If a project was funded, all the collaborators' profiles would be viewable in the public section of the MCubed website. In practice, researchers who did not want to have their profile publicly accessible could simply not post or collaborate on MCubed projects. Those who did participate, but did not want extra information about themselves or their projects publicly available, had the option to reduce all information to a bare minimum before the project was posted to the public side of the MCubed website.

The idea of having public and private versions of a website or profile pages is not new to general purpose social networking sites. So far, very few RNSs are built to be both publicly and privately accessible. Some previously built RNSs have been developed for the express purpose

of being publicly accessible (Cohen, 2007; Kahlon et al., 2014), while others have been specifically built to be only accessible within an institution, or within a researcher's social network (Bedrick & Sittig, 2008; Boland et al., 2012). While MCubed was built to be both publicly and privately accessible, individual researchers did not make the choice of how their profile was displayed. I suggest that future RNS systems default to privately accessible profiles while giving researchers the option to make their profiles publicly accessible, which is typical in many other social networking systems.

2.2.3.3   Implications for Incentivized RNSs

In general, anyone designing a system that offers incentives for certain behaviors should carefully consider what behaviors they are actually encouraging. Systems are designed with certain goals in mind. Technical systems in particular are built around certain rules, and those rules are based on the system goals. RNSs are built to encourage collaboration, and the details of how those systems are implemented change, based on the goals of the RNS.

For example, the goal of many of the RNSs in previous studies was to provide a way for researchers to find collaborators, regardless of their collaborator's academic discipline. In contrast, the goal of the MCubed program was to increase collaboration across academic disciplines. The question was then how to define the boundaries of an academic discipline. In the case of MCubed, the discipline was defined as the department where a researcher had their primary appointment. By this definition, MCubed was successful in encouraging collaboration across multiple schools and colleges. The question is, what would have happened if academic discipline had been defined some other way?

If MCubed collaborators are not finding each other through the MCubed website, then that begs the question of whether the website was more than a combination marketing and book-keeping system. One option is to spend more to implement a better search functionality, such as the synonym matching suggested by Schleyer, et. al. {Schleyer:2012vv}. However, if researchers are not even looking for collaborators on the MCubed website, perhaps spending money on improving the search functionality is wasted. Currently, there is a prevalence of anecdotal evidence and lack of systematic evidence supporting the claims that RNSs solve the problem of finding collaborators. Perhaps RNSs are not the global solution that the current proponents claim. While technical tools can provide innovative solutions to many problems, this

study shows that there is still value to the time honored approach of leveraging personal and professional networks. Social media has many advantages in terms of marketing or staying in touch with friends and acquaintances. On the other hand, it takes a much more concerted effort to find a trustworthy partner that is required for effective collaboration, as anyone who has tried online dating can attest. Perhaps RNSs are not the right approach, and it is time to look for something new.

2.3 Study 2: Institutional Support for Forming Interdisciplinary Collaborations

A key focus of the MCubed design was to encourage interdisciplinary collaboration by removing constraints imposed by the funding process (e.g., "following the money"). In theory, there were three requirements for funding: a) a researcher must commit his or her token to a project, b) two other researchers must also commit their tokens, and c) the three researchers must represent two or more schools or colleges. With three faculty members each committing a $20,000 token, the total amount available for a project was $60,000. Additionally, the Rackham Graduate School agreed to provide $3,000 to offset the cost of hiring a single graduate student for individual researchers. The MCubed administrators intended this amount to be enough to hire one student or post-doc.

The MCubed effort offered an opportunity to study the early stages of many small-scale interdisciplinary collaboration projects across diverse problem areas. Much of the previous research has focused on either large-scale collaborations or on in-depth studies of a single collaborative team. In both cases, previous research studies typically compared only two to four different fields.

2.3.1 Methods

2.3.1.1 Participants

The population for this study was the MCubed token holders, particularly those who were actively creating projects and committing their tokens to projects on the MCubed website. One of the primary goals was to understand how the rules and constraints of the MCubed initiative and the participating units, or the larger social context, affected the behavior of the token holders. As mentioned previously, each U-M school, college, or institute that participated in MCubed determined which faculty members were eligible for a token. The eligibility requirements ranged

from only tenured faculty, to almost any faculty member who was active in research. Because each unit varied in how it implemented its portion of the MCubed initiative, I also studied the various units that participated in the MCubed initiative. This provided a critical component of the social context surrounding the individuals who participated in MCubed. To further understand the larger social context, I also observed and interacted with members of the MCubed administrative team.

2.3.1.2 Data sources

Data for this study fell into two general categories: content created by the MCubed administrative team and MCubed website log files. First, I studied the press releases and blog entries posted on the website, as well as any descriptive or informative web pages. This gave me insight into the goals and actions of the MCubed administrative team. Second, I studied the MCubed website log files, which recorded every action a visitor took on the MCubed website. The website log files contained the type of information normally found in log files: a user identifier, a timestamp, the current page, the referring page, and a description of the type of action the user was taking on the website. Third, I saved the full html code for pages that listed MCubed token holders by unit, and all projects created on the MCubed website.

In addition to the website, I also attended numerous MCubed information sessions and MCubed Symposia. Attending the information sessions allowed me to learn about some of the challenges faced by token holders and unit administrators. At the same time, I also gained a more detailed understanding of the MCubed administrative team's goals, as well as how the rules they implemented supported those goals.

2.3.1.3 Procedure: Trace ethnography

I began observing the MCubed website in September 2012, about a month before it was first opened to token holders in October 2012. This gave me the opportunity to interact with the website and get to know the tools that would be available to the token holders as the website developers were finalizing the testing of those tools. At the same time, I had complete access to the website log files. To understand individual items within the MCubed website log files, I performed a variety of actions on the site before it was opened to token holders. During this time I fully explored the functionality offered by the MCubed website. I also observed the web logs created by the website developers and MCubed administrators as they tested the system prior to

launch. Once the website was opened to token holders, I regularly studied the website logs. This allowed me to see the coordinated actions of researchers looking for collaborators on the MCubed website. I also read the descriptions of all new and updated projects on the website, as well as the token holder profiles of any project collaborators.

At the same time, I attended multiple informational sessions designed to promote the MCubed program to university researchers and to inform them about using the website. Once the website was opened for active use, I tracked and read all new and updated project descriptions, as well as comments left on those projects. I also noted any changes to the collaborators on a project, particularly in the time periods surrounding the distribution of MCubed funds. Finally, I combed through every press release, news article, and blog post about MCubed. These activities provided much of the social context necessary to understand the detailed activity accounts I observed on the MCubed website.

These ethnographic observations often provided key insights that I later verified through a more quantitative analysis of the MCubed website log files. The log files and data sets derived from the log files were stored in an SQL database for later retrieval and processing. A variety of scripting languages (PHP, Python, D3 Javascript visualization library) and the IBM SPSS statistical package were used for additional data processing and analysis.

2.3.2   Results: The evolution of MCubed

In this section, I look at how MCubed funds were distributed to researchers. Third, I provide the differing levels of use in various groups who used the MCubed website.

2.3.2.1   Variations in unit distribution of tokens and funding of those tokens

Each University of Michigan department chose to define who was eligible for an MCubed token, with some departments limiting token holders more strictly than others. The units participating in MCubed varied greatly in the number of tokens distributed, and the maximum number of tokens they were willing to fund. Some units agreed to fund only a few tokens. These included Art & Design, Education, and Music Theatre & Dance. In contrast, some units—such as Information, Dentistry, and Kinesiology—agreed to fund any token holders who chose to participate in MCubed. Table 2-6 shows the number of token units distributed and the maximum number of tokens each unit agreed to fund at the time the MCubed website opened.

37

Unit	Number of Tokens Distributed	Maximum Number of Tokens Funded
Architecture & Urban Planning	65	20
Art & Design	37	3
Business	80	10
Dentistry	29	30
Education	12	5
Engineering	387	200
Graham Sustainability Institute	1	1
Information	36	30
Institute for Social Research	94	7
Kinesiology	13	10
Law	26	4
Libraries	154	4
Life Sciences Institute	21	20
LSA: Humanities	*	100
LSA: Natural Sciences	*	100
LSA: Social Sciences	*	100
Medicine	525	180
Music, Theatre, & Dance	133	2
Natural Resources & Environment	38	25
Nursing	30	10
Office of the Vice President for Research (OVPR)	30	20
Pharmacy	29	20
Public Health	153	140
Public Policy	7	6
Social Work	53	10

Table 0-6: Token distribution and funding by unit.

* The number of tokens distributed in LSA units varied throughout the time MCubed distributed funds due to the way LSA distributed tokens.

By the time MCubed finished distributing funds, there were 2,154 token holders throughout the University of Michigan. Most departments distributed MCubed tokens in Fall 2012. In contrast, the College of Literature, Science, and the Arts (LSA) distributed tokens throughout the time MCubed distributed funds, because of the requirement that LSA faculty specifically request MCubed tokens. The U-M Provost's office originally provided funds for 250 projects, and each project involved three tokens, each worth $20,000. Later, the total number of

potential projects funded was reduced to 225 to cover MCubed administrative costs. Because each funded token holder received a total of $20,000, minus administration costs, 675 tokens could potentially be funded.

2.3.2.2 *First funding phase (semi-random selection)*

Originally, MCubed was conceived as a first-come, first-served funding process. The idea was that researchers would post a project, get two more collaborators, request funds, and the project would be funded within weeks of the request. This process would work well if there was a steady, but not overwhelming, stream of interest. It quickly became apparent to the MCubed administrators that a first-come, first-served process could cause a lot of problems. The MCubed website was experiencing more activity than initially expected (MCubed, 2012a). Within a day of opening the site, almost 30 projects had been proposed. Despite the buy-in requirements for individual faculty, researchers were still interested in getting extra research dollars.

On October 10, 2012, the MCubed team announced funding for fifty projects. Additionally, eligible funding requests would be granted through an "essentially random" selection process (MCubed, 2012a). This decision was probably made to reduce the chances of web server and personnel overload. As stated in the MCubed blog post, "We realize it could involve thousands of researchers waiting by a computer, hand hovering over the return key, getting set to repeatedly press it when the cubing function becomes active" (MCubed, 2012a). A first-come, first-served funding mechanism that opened at a certain time on a certain day could certainly create traffic overload on a site designed under the assumption of a steady, middling level of traffic. As the MCubed team put it in their October 10, 2012 blog post, "We now think an essentially random draw of eligible cubing requests would cause less angst and uncertainty" (MCubed, 2012a).

The process worked in the following way. Project creators with projects that met the funding requirements (three collaborators from at least two different units, including the project creator) could indicate their interest in competing for one of the fifty available funding slots. This functionality would be made available for one week. After that week was over, the MCubed team would distribute the funds according to a yet-to-be-announced random process. About a month later, on November 6, the MCubed team announced that during November 12–19 project creators could start requesting MCubed funds.

According to the November 27, 2012 blog post, the "semi-random" process would take place the next day in two stages. During the first stage, the semi-random selection algorithm would "ensure that every school, college, or other participating university unit is represented in at least one project" (MCubed, 2012b). This was the semi-random portion of the project selection process. Once all participating units were represented in the selected projects, the remaining funding slots would be filled completely randomly (MCubed, 2012b).

Without the semi-random nature of the drawing, Medicine would have received just over one third of the available projects, and Engineering and LSA-Natural Sciences combined would have received another third. With the luck of the draw, some units would not have been selected to receive any MCubed funds. The semi-random lottery process would advantageously distribute funding relatively evenly among the university units, at least in steps 2 and 3 described below.

Based on documents posted on the MCubed website, the semi-random lottery worked as follows (Burns, 2012):

Projects requesting funding were assigned a random number, generated using a gaming industry approved random number generator. The projects were then sorted using the assigned random numbers, and the algorithm looked at each project in order.

First, the algorithm tried to pick projects with a project collaborator from each unit. If one of the project collaborators was from a unit that had not been seen previously, the project was selected for funding. Otherwise, the project was skipped. Available token counts were updated. If a unit ran out of fundable tokens, all later projects with token holders from that unit were skipped. This process would repeat until the algorithm reached the end of the list.

Once all the units were represented in funded projects, the algorithm started over again from the beginning of the list, selecting all projects encountered until the number of funded projects reached 50. Any projects that had two tokens from a unit with only one remaining fundable token were skipped.

The MCubed team ran through this process multiple times prior to the official run, to ensure that each unit was represented in at least one funded project.

Starting at 10:00 am on November 28, 2012, projects were selected to receive MCubed funding. About every minute, a project was selected and announced through Twitter. Table 2-7 shows the number of projects funded in the semi-random selection process.

Unit	Number of Projects Requesting Funding in 1st Phase†	Total Projects Funded in 1st Phase
Architecture & Urban Planning	2 (1.6%)	0 (0%)
Art & Design	1 (0.8%)	1 (2.0%)
Business	3 (2.4%)	1 (2.0%)
Dentistry	7 (5.5%)	2 (4.0%)
Education	3 (2.4%)	1 (2.0%)
Engineering	19 (15.0%)	11 (22.0%)
Information	4 (3.1%)	1 (2.0%)
Institute for Social Research	1 (0.8%)	1 (2.0%)
Kinesiology	1 (0.8%)	1 (2.0%)
Law	1 (0.8%)	1 (2.0%)
Life Sciences Institute	0 (0%)	--
LSA: Humanities	2 (1.6%)	1 (2.0%)
LSA: Natural Sciences	13 (10.2%)	4 (8.0%)
LSA: Social Sciences	3 (2.4%)	2 (4.0%)
Medicine	48 (37.8%)	15 (30%)
Music, Theatre, & Dance	1 (0.8%)	0 (0.0%)
Natural Resources & Environment	6 (4.7%)	3 (6.0%)
Nursing	1 (0.8%)	1 (2.0%)
OVPR	1 (0.8%)	1 (2.0%)
Pharmacy	4 (3.1%)	1 (2.0%)
Public Health	4 (3.1%)	1 (2.0%)
Public Policy	2 (1.6%)	1 (2.0%)
Social Work	0 (0%)	--
Total	127 (100.0%)	50 (100.0%)

Table 0-7: Number of projects funded in the semi-random selection process on November 28, 2012

Figure 2-2 presents the above information in a visual format. Circles indicate the home unit of the project creator. Lines and loops indicate collaborators. The size of both lines and circles is proportional to the total number of projects funded. Arrows on the lines indicate which unit received tokens. Each unit was assigned a unique color to aid in determining which unit was contributing collaborators to another unit's projects.
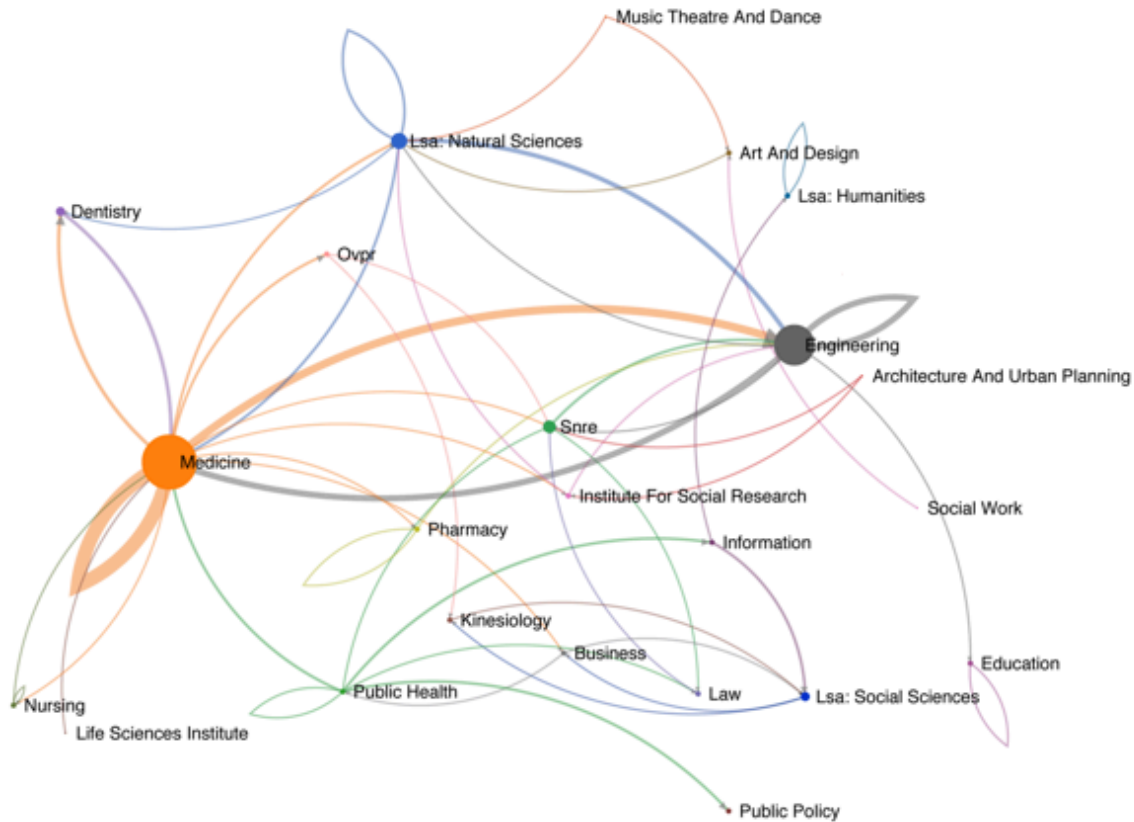
Figure 0-2: Network diagram showing results of the first phase of MCubed funding distribution

After the funding lottery process was complete, there was a noticeable slant toward units that had the largest amount of funding available, and toward individual researchers who could afford to fund the individual portion of an MCubed project. Medicine and Engineering had the most projects funded. Engineering was the big winner in terms of the overall portion of projects from a given unit funded in the first phase. Engineering had 15% of the proposed projects requesting funding, and 22% of the projects funded in the first funding phase. Despite this, the emphasis on funding projects from every unit did ensure that smaller units with only a few projects, such as Art and Public Policy, were able to participate in the first phase of MCubed. As a result, the large units, such as Medicine and Engineering, did not dominate the first MCubed funding phase as much as they did in later funding rounds. In this respect, the semi-random process worked to distribute MCubed funds across the university, and gave the smaller units a better chance to participate than they would have had otherwise.

Table 2-2 shows that a unit had to have at least 5% of the projects remaining at the start of step three to guarantee that the unit would get project(s) funded in the third step of the selection algorithm, which was a purely random selection. In this step, Medicine got 43% of the remaining funding slots. Engineering did very well, receiving a third of the remaining projects selected in step three. Eight units had less than 5% of the projects left over at step three of the selection algorithm, so this was essentially a random selection between one of those eight units. The only unit that got a project funded with less than 5% of the projects remaining was LSA-Social Science.

2.3.2.3 Second Funding Phase (random selection)

On December 4, 2012, the MCubed team announced the opening of the second cubing phase (MCubed, 2012c). At that point, project creators could again start requesting funds for their projects. Because the process of choosing which projects to fund went smoothly in the first funding phase, the MCubed team decided to fund 150 projects rather than 50. If more than 150 projects requested funds, the process for picking projects to fund would be the same as the semi-random lottery from the first phase. Otherwise, the selection process would be completely random. The funding selection algorithm would run until either all eligible projects were funded, or 150 projects had been selected to receive funding, whichever came first. The end of this period was December 17, 2012. The MCubed team also announced that the Libraries unit had joined the MCubed program for the second funding phase. Libraries had agreed to fund four tokens. Project creators who had requested funding in the first funding phase, but were not selected in the semi-random lottery, would need to re-indicate their interest in competing for one of the 150 available funding slots.

While only one unit had run out of tokens in the first funding phase, many other units were close to running out of tokens. For example, Art & Design had one remaining fundable token, and Education had three. Because some units were close to reaching the maximum number of tokens they had agreed to fund, the MCubed team suggested that token holders strategize to maximize their chances of getting funding. To make this easier, the MCubed team redesigned the token status table on the website in order to make it clear which units were likely to run out of funds in the second funding phase (MCubed, 2012c).

A total of 139 projects requested funding by the time the request period was over on Dec 17, 2012. The MCubed team selected the projects to be funded on December 18, 2012. One hundred seventeen projects were funded in the second funding phase. Some of the projects requesting funding were not selected because multiple units—Art & Design, Education, Libraries, and Medicine—ran out of fundable tokens during the random selection process.

The second phase of the selection process did not go as smoothly as the first. Evidently, there was an error in the random selection algorithm, because two Medicine tokens were still available after the selection process had run. The next morning, December 19, another project was selected using the random process, which brought the total number of funded projects to 117. According to the weblogs, the second random selection pulled up two projects. The first project (Medicine, Medicine, Public Health) selected was skipped and the second project (Medicine, Medicine, LSA-Social Sciences) was funded. It is possible that the first project was disqualified for some reason, or that the algorithm was not run correctly the first time.

Sometime after project collaborators received their funding notifications, one project with two Medicine tokens decided to withdraw from the MCubed program (MCubed, 2013b). The other collaborator on that project was a Research Investigator from Public Health. Because Medicine had run out of tokens, two more potential projects, originally not selected in the second phase random lottery, could be funded. The MCubed team re-ran the random lottery process on the 22 remaining projects and two more projects were funded, bringing the total number of funded projects to 169, including the project that dropped out of the MCubed initiative (MCubed, 2013b). Table 2-8 shows the token distribution after this change in funded projects. Figure 2-3 shows how the units interacted in the second MCubed funding phase.

Unit	Number of Projects to Request Funding in 2nd Phase	Total Projects Funded in 2nd Phase
Architecture & Urban Planning	3 (2.2%)	2 (1.7%)
Art & Design	2 (1.4%)	1 (0.8%)
Business	3 (2.2%)	2 (1.7%)
Dentistry	7 (5.0%)	7 (5.9%)
Education	2 (1.4%)	1 (0.8%)
Engineering	20 (14.4%)	17 (14.3%)
Information	4 (2.9%)	3 (2.5%)

Institute for Social Research	1 (0.7%)	1 (0.8%)
Kinesiology	0 (0%)	--
Law	1 (0.7%)	1 (0.8%)
Libraries	3 (2.2%)	2 (1.7%)
Life Sciences Institute	0 (0%)	--
LSA: Humanities	2 (1.4%)	2 (1.7%)
LSA: Natural Sciences	14 (10.1%)	13 (10.9%)
LSA: Social Sciences	4 (2.9%)	4 (3.4%)
Medicine	59 (42.4%)	51 (42.9%)
Music, Theatre, & Dance	--	--
Natural Resources & Environment	4 (2.9%)	3 (2.5%)
Nursing	1 (0.7%)	0 (0.0%)
OVPR	0 (0.0%)	--
Pharmacy	3 (2.2%)	3 (2.5%)
Public Health	5 (3.6%)	5 (4.2%)
Public Policy	1 (0.7%)	1 (0.8%)
Social Work	0 (0%)	--
Total Projects	139 (100.0%)	119* (100.0%)

Table 0-8: Projects funded in the 2nd phase (random selection)
* This total includes the project that was funded but decided to drop out of the MCubed program.
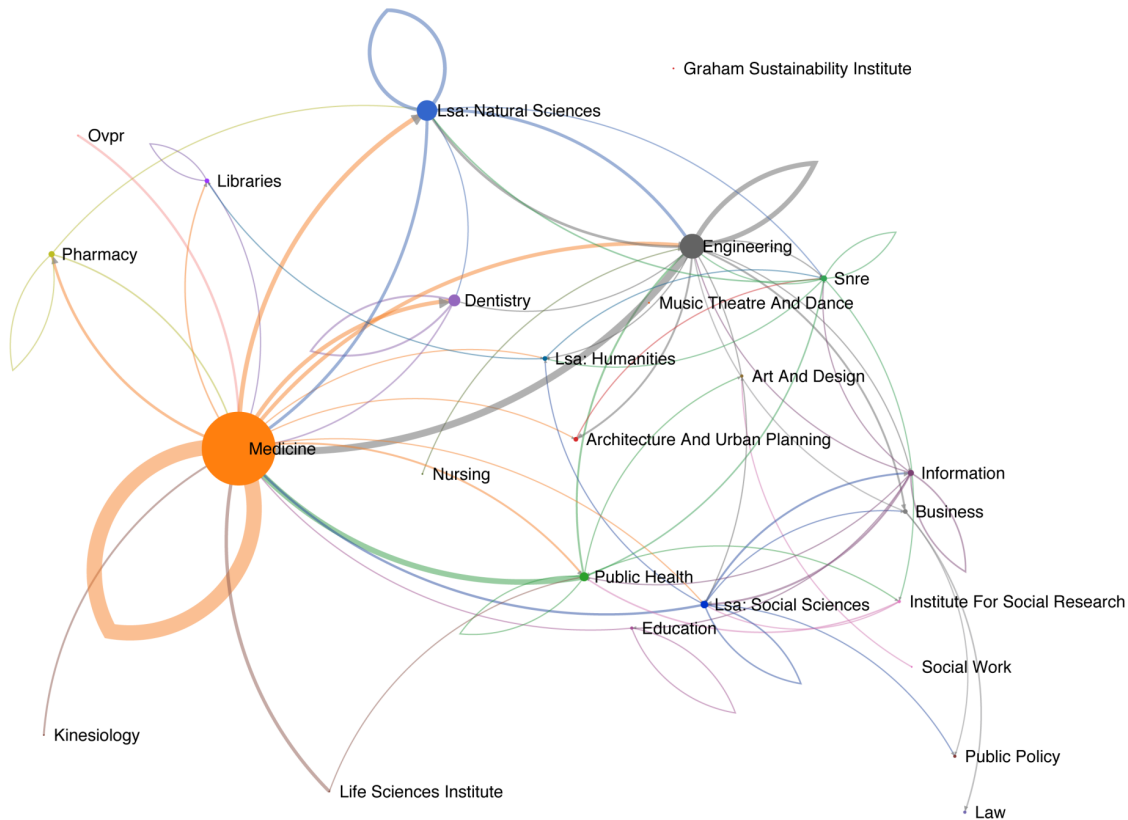
Figure 0-3: Network diagram of the results of the second phase of MCubed funding distribution.

Medicine received the highest number of selected MCubed projects. Medicine would have represented an even larger portion, had it not run out of money to fund MCubed projects. It is likely that had Medicine known how popular the MCubed program would be with its faculty, the administration would have increased the number of projects it was willing to fund. Engineering and Natural Sciences projects also received a significant portion of the available MCubed funding. Dentistry received about half the number of funded projects than did LSA-Natural Science. Smaller units with fewer funds available simply proposed fewer projects. For example, LSA-Humanities only proposed 2 projects, both of which were funded. Humanities researchers often have fewer places to request funds, and the amount they can request is also generally less. Moreover, LSA-Humanities required individual token holders to pull money out of their own research funds, like researchers from multiple units. It is likely, therefore, that this requirement prevented many of their researchers from participating.

2.3.2.4   Third Funding Phase (First-come, first-served)

On February 13, 2013, the MCubed team announced that the third funding phase would open on February 27, 2013 (MCubed, 2013a). Unlike the previous phases, the funding in this phase would be distributed on a first-come, first-served basis. According to the MCubed blog, the MCubed team thought that the high volume of website traffic experienced in the first two cubing phases would be less pronounced, because in the second phase, fewer projects requested funding than the number of funding slots available (MCubed, 2013a). At this point, MCubed would distribute funding for up to 57 more projects.

The MCubed team made some adjustments to the MCubed website in order to make the process of selecting collaborators more transparent. The key adjustment was to include warning messages when a project had tokens committed from a unit that had exhausted its supply of fundable tokens. The team also updated the token status table to make it clear which units had run out of tokens by greying out the units with no more fundable tokens.

The start of the first-come first-served stage saw an initial burst of activity, with 13 projects requesting funding within 30 minutes of the open of the third phase. After two days, 19 projects had successfully requested funding. During this initial activity the Business unit ran out of fundable projects. After the initial burst there was a month-long lull in projects requesting MCubed funds, which took place during the last half of the Winter 2013 semester. Funding activity picked up again at the end of the semester.

The number of projects requesting MCubed funds peaked in May 2013, after winter classes were finished, with 14 projects requesting MCubed funds through May. There were a few potential reasons for this bump in activity during May. First, with the winter semester completed, token holders could turn their focus from teaching to research. Second, the MCubed team announced that MCubed projects employing graduate students could apply for reimbursement from the Rackham Graduate School, which had been promised at the beginning of the MCubed program. Projects wanting to receive this funding had until May 24, 2013 to apply for the Rackham funding (MCubed, 2013c). Any funds left over would be distributed on the same first-come, first-served basis as the MCubed funds.

In late July, the Graham Environmental Sustainability Institute decided to participate in MCubed. The Graham Institute agreed to distribute and fund a single token, and that token went

to the Director, Don Scavia. Previously, Dr. Scavia had a token through Engineering. Dr. Scavia committed his token to a project with two Engineering collaborators.

On July 25, 2013, the MCubed team sent out a press release titled "Last call for MCubed seed funding," which was published in the University newspaper on July 31, 2013. This press release reminded eligible researchers that the last day to request MCubed funding was August 31, 2013 (Moore, 2013). Between July 31 and August 31, there was another small bump of nine more projects, bringing the total number of projects to receive MCubed funding to 222. Table 2-9 and Figure 2-4 show the token distribution for the third phase of MCubed.

Unit	Number of Projects Funded in 3rd Phase
Architecture & Urban Planning	2
Art & Design	--
Business	1
Dentistry	1
Education	--
Engineering	19
Graham Sustainability Institute	0
Information	2
Institute for Social Research	--
Kinesiology	1
Law	0
Libraries	--
Life Sciences Institute	0
LSA: Humanities	6
LSA: Natural Sciences	9
LSA: Social Sciences	3
Medicine	--
Music, Theatre, & Dance	--
Natural Resources & Environment	1
Nursing	2
OVPR	0
Pharmacy	1
Public Health	5
Public Policy	1
Social Work	--

Table 0-9: Tokens funded in the third MCubed funding phase
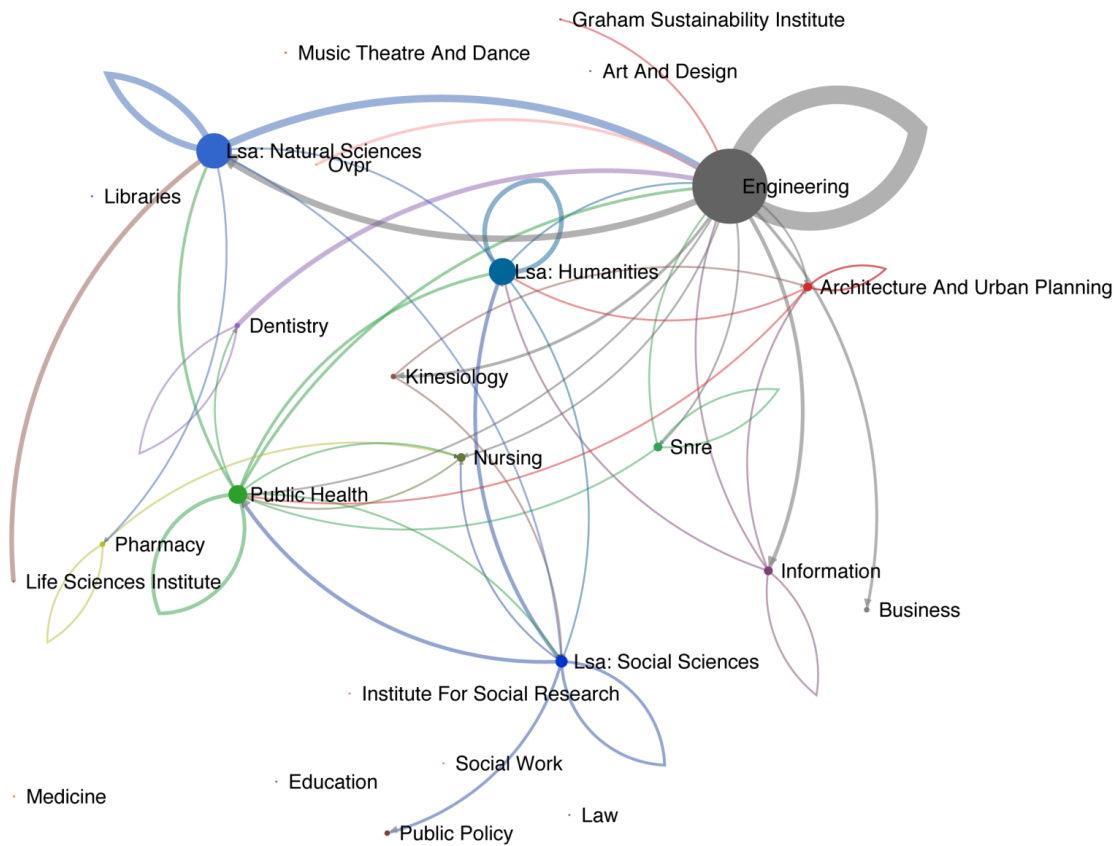
Figure 0-4: Network diagram showing the results of the third MCubed funding phase.

With Medicine no longer able to participate in MCubed, Engineering became the dominant unit. LSA-Natural Science also had high participation rates, with LSA-Humanities and Public Health also becoming significant players in the third funding phase. LSA-Humanities became more active in the third MCubed funding phase than it had been previously, creating almost as many projects as LSA-Natural Science. Tokens committed was a different story though, because the total number of tokens committed by LSA-Humanities scholars was half of the number of tokens committed by LSA-Natural Sciences.

Out of the 54 projects funded in the third funding phase, only nine were created in the first two funding phases (six in the first phase, and three in the second phase). Of those nine projects, five were funded on the first day of the third phase. Most of these nine projects had not received funding in the first or second phases due to a collaborator's unit running out of fundable tokens. In these cases, the remaining project collaborators were able to find another collaborator

from a unit that still had fundable tokens. In at least a few instances, collaborators from units that ran out of tokens remained on the project as non-token collaborators.

2.3.2.5 Overall

MCubed project funding required three collaborators from at least two different units. A total of 388 projects were created over the course of the MCubed pilot project. Of those, 252 met the funding requirement and 222 received funding through the MCubed program. Many projects that met the MCubed requirement were not funded. As a result, collaborators sometimes removed their tokens from those projects in order to work on new projects.

Projects	Number
Created	388
Filled	252
Received Funding	222

Table 0-10: Total number of projects created on the MCubed website

Some units were much more interactive across the university than others. LSA-Humanities could be considered an "ideal" MCubed unit in that, for their size, Humanities token holders collaborated with a large number of other units, contributing tokens to projects in four other units: Engineering, SNRE, LSA-Social Science, and Libraries. On their own projects, LSA-Humanities scholars had collaborators from eight different units, including Information, Public Health, and LSA-Social Science. In contrast, token holders from the Life Sciences Institute never created a single project, and only committed tokens to projects from three units: Medicine, Public Health, and Natural Science.

As shown in Figure 2-5, most project creators collaborated with someone else from their unit. A few units tended to be more interdisciplinary than others, using "number of units participating in a project" as a proxy measure of interdisciplinary research. The School of Natural Resources and Environment (SNRE) had the largest percentage (75%) of three-unit projects. Architecture and Urban Planning was the only other unit to have more three-unit projects than two-unit projects, with 60% of projects created by SNRE researchers including three different units. All units where at least 50% of the projects were three-unit projects were

smaller units. These were the School of Nursing, the School of Music, Theatre & Dance, the Law School, and the School of Kinesiology.
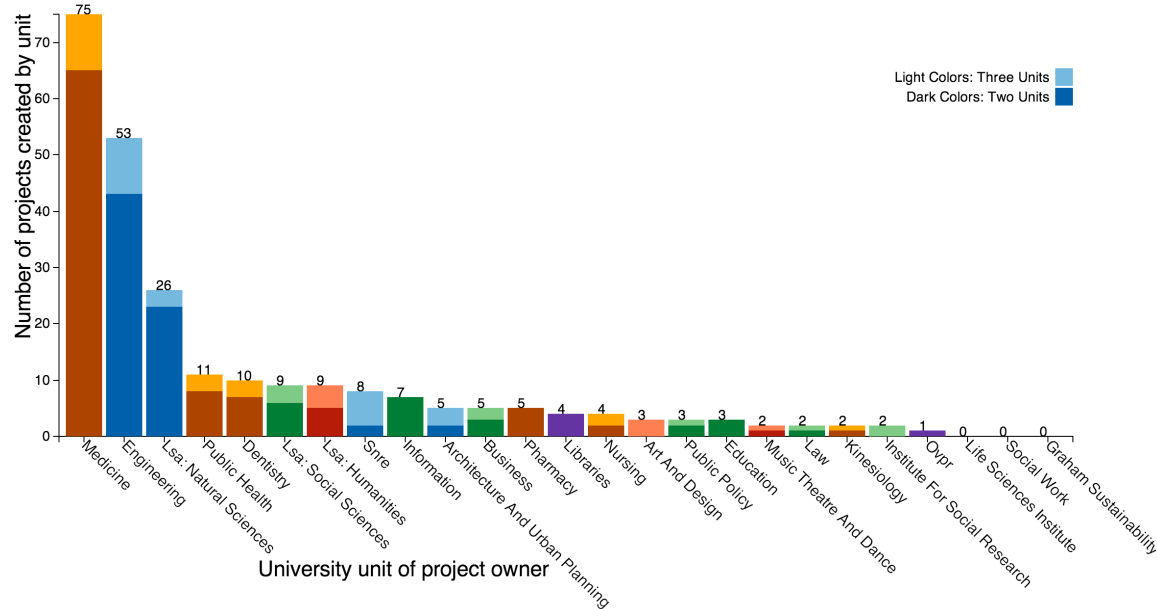
Figure 0-5: Number of collaborators per project with the requisite three tokens committed by sponsoring unit

2.3.2.6   *Shifting Collaborative Arrangements*

The combination of units limiting the number of tokens they were willing to fund, and the rules surrounding the different phases of the MCubed funding distributions, led to shifting collaboration patterns. This was most marked in smaller units, such as Art & Design or Education. Essentially, the limited number of funds distributed in the first phase, along with units running out of tokens in the second phase, led to many frustrated token holders.

For example, one SNRE researcher created a project to write a coffee table book about Michigan, and one of his collaborators was from Art & Design. The project had the required number of collaborators to compete for funding in the first MCubed funding phase, but it was not selected in that round. At that point, Art & Design had only one token left. With at least five different projects vying for that one funding slot, it was not surprising that this project was not funded in the second MCubed funding phase. After not being selected in either the first or

second rounds of funding, the faculty member removed all tokens from the project and deleted it from the MCubed site. In the third round, he committed his token to another SNRE project.

In the above example the token holder eventually found another project in which to participate, but other token holders in similar situations either dropped the project or looked for funds in other places. Another project, with two collaborators from Information and one from Medicine had a similar problem to the one described above. That project was not selected in the first funding phase due to the limited number of funding slots available. In the second phase, the Medical School ran out of fundable tokens. After that, one of the collaborators uncommitted his token from the project, and created his own project. The project creator did not find another collaborator to fill the space left by her colleague, and the project remained unfilled and unfunded through MCubed.

This story played in other projects as well, especially those with collaborators from the Medical School. It is possible that the Medical School administration did not realize how popular the MCubed program would be with their faculty. As a result, the Medical School ran out of fundable tokens late in the second MCubed funding phase. Despite this, Medicine still had the largest number of funded projects, and funded token holders, in the MCubed program.

Multiple projects created by University Library token holders were filled, but they did not receive funding because the unit ran out of tokens. Moreover, other projects with collaborators from University Library were not funded in the second phase. In one specific case, a library token holder contacted the project creator and asked to be included in the project. Unfortunately, the project was one of the multiple unfunded projects with collaborators from the University Library in the second funding phase. In the third round, the project creator found another collaborator who had worked with the two remaining collaborators on a previous proposal. This was probably the set of collaborators they had originally intended. In later symposia programs, the Libraries collaborator is listed as a non-token collaborator.

2.3.3 Discussion: Institutional support for forming interdisciplinary collaborations

A key focus of the MCubed design was to encourage interdisciplinary collaboration by removing constraints imposed by the funding process (e.g., "following the money"). MCubed wanted a process free of the influence of funding and review struggle. Essentially, the MCubed team wanted teams to form and propose projects independent of funding and review constraints.

In theory, there were three requirements for funding: a) a researcher must commit his or her token to a project, b) two other researchers must also commit their tokens, and c) the three researchers must represent two or more schools or colleges. In reality, each unit that participated in MCubed added extra requirements, some more onerous than others. Some units explicitly excluded certain faculty members from participating. For example, the College of Engineering did not allow research track faculty to participate in MCubed. Units also varied dramatically in both the number of tokens funded and the amount of individual funds token holders were required to contribute. All these various policies shaped the contours of the resulting collaborations, and most likely the project content as well.

The evidence presented in this study suggests that the creation of teams was strongly conditioned on unit-level policies. Many more "cubes" were formed and joined by faculty in units with generous support for faculty participation. In contrast, other teams and projects were precluded by the lack of unit support. Effective collaborators and ideas were excluded from receiving MCubed funds, because they had the back luck to be in a low resource or low participating unit. Instead, the projects funded by MCubed were largely collaborations between Engineering and Medicine, which were already resource rich units. These large variations in institutional support served to undermine the MCubed goal of freeing collaborators from the need to follow the lead of funding agencies. Instead of a process that was free of the influence of funding and review struggle, the process inserted funding in a potentially damaging way by helping the units that were already resource rich to get even richer.

2.4   Conclusion

This chapter has highlighted MCubed, a pilot project at the University of Michigan, designed to encourage new interdisciplinary collaborations. A major aspect of MCubed was an RNS to help researchers find collaborators for those new collaborations. The emphasis of this chapter has been on how the various collaborations between researchers participating in the pilot project initially formed. I illustrated how researchers were using the RNS, and hypothesized reasons for those patterns of use. Finally, I suggested design implications for both future iterations of MCubed and RNSs in general. Limitations and future work are discussed in Chapter 5.

This chapter addressed two of the questions raised in Chapter 1. The first question addressed was whether those who wanted to collaborate could find collaborators. This portion of the study reflected the MCubed goal of encouraging "new groups" to work together. Based on the website log files, most researchers participating in MCubed worked with people they already knew. This calls into question the usefulness of RNSs in finding collaborators, and indicates that the website should have provided more support for those who needed to find collaborators.

The second question addressed was how support from the institutional environment affected participation in MCubed, which was designed to encourage interdisciplinary collaborations. I found that variations in unit distribution and funding of MCubed tokens dramatically impacted participation in interdisciplinary collaborations funded through MCubed. This impact was particularly dramatic when looking at the network diagrams showing the number of projects created by each unit, as well as the proportion of two- and three-unit projects by the project creator's unit. I explore this question in greater detail in Chapter 5.

In the next chapter, I will look at two of the questions raised in Chapter 1 through the lens of research output. First, I will look at what output is typical for researchers who were funded through MCubed. Second, I will look at the output of the MCubed projects themselves. This will give me insight into whether a department will view the output from a particular interdisciplinary collaboration as beneficial, and therefore which types of outputs are supported in different departments and, by extension, academic disciplines.

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Chapter 3

Scholarly Arc – The Process Behind Early Research Output

3.1 Introduction

Chapter 3 does not directly address any of the open questions described earlier. However, it lays the groundwork that will allow me to explore the third question: Does team performance vary with the degree of interdisciplinarity? Previous research has focused on peer-reviewed publications, such as journal articles, as a definitive measure of output. A disadvantage of this approach, particularly in my case, is the long lag time that can occur between the inception of a project and its final realization in the form of a published result. As a pragmatic matter, I needed to capture the production of meaningful outputs along the path toward a published result— because the timeframe of my study suggested a truncated distribution of publications (i.e., many are likely to occur outside the interval of my investigation).

While the purpose of this chapter was operational rather than addressing a particular research question, insights regarding the institutional environment surrounding MCubed collaborations through the lens of project output emerged during the course of the study. The MCubed projects generated a wide range of outputs. This is not surprising because the funded MCubed projects spanned the full range of creative activity at U-M, as some of the graphs presented in the last chapter show. During the process of conducting this study, it occurred to me that the departmental perception of the benefits of interdisciplinary collaboration depends on whether a department values the output from an interdisciplinary project.

For example, one project funded through MCubed had collaborators from Art & Design, Music Theatre & Dance, and LSA-Natural Sciences. The output from this project was a

multimedia art installation, and multiple audio recordings. While these outputs were likely well received by the schools of Art & Design and Music Theatre & Dance, the outputs would probably hold little weight in a tenure case for the project's high-energy physicist. Fortunately for him, he already had tenure. More generally, publishing in venues not recognized by a researcher's department and colleagues could directly impact whether he or she achieves tenure. This measurement bias becomes even more pronounced when collaborations include scholars from fields such as art or architecture, which do not publish in any traditional venue. The output from collaborators who come from widely disparate disciplines risks going unrecognized or valued in any department—and therefore discarded—no matter the actual value of that output.

In this chapter, I present the shortcomings of current methods of measuring successful research, and present a method that overcomes many of these problems. Much of the previous work on the research process has used the number of peer-reviewed publications or citations as a proxy measure for successful or significant research. However, these measures only apply to the highly-polished final output of a research project. Publication and citation counts have some critical limitations in that they do not depict the messy reality of the research process, which is dynamic, iterative, and full of false leads. Traditional measures of research output that rely on publications are temporally distant from the actual research process. This was a major shortcoming for my purposes, since many of the MCubed projects would not have time to produce a peer-reviewed publication between the time the project was funded (in early 2013 for most projects) and early in 2015, when time data was collected for the analysis presented in the third chapter.

To overcome this limitation, I decided to study a wider range of outputs than traditional measures allowed. Therefore I needed to formalize the range of outputs I considered in some way. To address this, I have constructed an arc of scholarly output that tracks the trajectory of a research project from the first stages of receiving informal feedback to the final stage of peer-reviewed publication, or other field-based outputs. My goal in constructing this arc was to create a temporally proximate measure of the research process that maps the path from the start of a scholarly project (research or otherwise) to completion. This approach focuses on the process of research, rather than the final outcomes of that research.

The rest of this chapter is organized as follows. First, I describe the traditional and alternative measures of a research project's success, and the weaknesses associated with those

measures. Next, I describe the methods I used to create a measure that addresses some of those weaknesses. This is broken into three parts: 1) collecting CVs for analysis, 2) categorizing the outcomes listed on those CVs through content analysis, in order to create a measure of research output, and 3) verifying the measure by tracking research project outcomes in multiple CVs and projects. Finally, I discuss limitations and future work.

3.2   Previous Work

Although publication and citation counts are generally considered the gold standard, there are some critical limitations to these measures. First, and most important, it often takes years for a research project to produce any publications, which means that anyone seeking to evaluate the outcomes of that project must typically wait until the project is completed. Second, publication and citation counts differ significantly across scientific domains, thereby making comparisons across fields difficult.

3.2.1   Traditional measures of research output

The first problem with publication and citation counts is that the time it takes to move from the initial write-up of research results to final publication can vary widely by field. In fields where conferences are the main publication venue—such as computer science—research results may be published as quickly as a year after data collection starts, in the best cases. In other fields, researchers may go back and forth with reviewers multiple times before acceptance, so it is not unusual for publication to take three to five years, or more (Nederhof, 2006). In either case, researchers may submit a paper to a series of conferences or journals for years, starting the whole process over from scratch each time, before a paper is finally accepted. Research in social science and humanities tends to take longer than research in natural science (Nederhof, 2006). Citation counts are even more problematic when it comes to timeliness, since those may not accumulate until well after the project is completed. Moreover, it may take five to ten years before those in a field realize the full impact of a paper (Terry, 2014).

The second problem is that publication and citation counts are not comparable across fields. In some fields, the average researcher normally publishes three to five high-quality papers every year. In other fields, even highly productive and elite researchers can only turn out one publication every year or two. Citation counts are just as variable. For example, the most cited article in ACM CHI (Conference on Human Factors in Computing Systems) was cited over

1,000 times, and the average paper is cited about 9 times (ACM, 2014). In contrast, the most cited publication in the American Journal of Orthodontics and Dentofacial Orthopedics was cited less than 100 times (Elsevier, n.d.). While it is likely that neither reported count is entirely accurate, the difference in magnitude speaks to the challenge of comparing citation counts across disciplines. To compound this problem, some journals are not included in the ISI/Thompson Web of Science, which means they are not included in citation counts (Englander, 2013a).

Finally, publication and citation counts only deal with textual materials, while other outputs, such as data products, are often ignored (Van De Sompel, Payette, Erickson, Lagoze, & Warner, 2004). Publication is only one measure of a successful research project (Schunn, Crowley, & Okada, 2002). Earlier research outputs—such as patents and working software or hardware prototypes—are often equally valuable, albeit in different ways. Simply presenting intermediate research results at conferences serves to help researchers refine ideas, and increases the visibility of the institution supporting the researcher (Garvey, Lin, Nelson, & Tomita, 1972d). In some fields, even agreeing on what aspect of the scholar's work should be evaluated can be a source of contention (Hellström, 2010).

3.2.2 Alternative measures of research output

Alternate measures of research project outcomes have been suggested, including co-citation analysis and download metrics. Co-citation analysis identifies groups of publications that are cited together in later publications, and is often used to measure the growth of research centers (Hicks & Melkers, 2013). Download counts are also growing popular. Some researchers argue that the number of times an article is downloaded more accurately measures the usefulness of that publication (Rowlands & Nicholas, 2006). However, these alternate measures have the same weaknesses as the traditional measures. Both suffer from the extended time frame problem discussed above, because each alternative measure requires that a research project is mature enough to be published. The alternate measures also suffer from the problem of comparison across fields, because there will also be dramatic field differences in these measures.

Part of the problem is that different measures pick up on different types of outcomes by different actors at different times, so narrowly-defined measures can bias the evaluation of a project's success (Lane, 2010; Nelson, 2012). Some research has attempted to measure citations from non-traditional sources. For example, one study measured the number of publication

citations from websites (Vaughan & Shaw, 2005). While this certainly measures the wider impact of a research project beyond academic circles, it suffers from the same weakness as the other alternative measures presented above, in that the research must be published and cited before the measure can be effective.

The measures described up to this point all depend on research published in a peer-reviewed venue, and cited by colleagues, in order to be counted. By definition, only successful projects are recognized as creating new knowledge. The reality is that even when researchers fail to publish, knowledge is still created. 'Failures' are often as instructive as successes, but 'failure' is more difficult to measure (Lane & Bertuzzi, 2011). Research is much messier than what is depicted in highly polished, peer-reviewed papers. Even successfully published research often progresses in fits and starts, rather than the smooth path that is usually portrayed in published articles.

Any measure using publication or citation counts is best applied to research where the process of gathering results is complete. These measures are temporally distant from the actual process of doing research. All the measures mentioned to this point fail to capture processes that occur in the early stages of a research project. While peer-reviewed publications and citations certainly measure a research project's impact on the larger field, they are often the final product of years of thought and discussion surrounding a research project. Those years of thought and discussion are critical to the scientific process. Without them there is no final publication for anyone to cite.

Measuring the final output of a research project is certainly valuable, but there is also value in looking at earlier outputs. When attempting to assess an event or process, researchers in most fields prefer to use data that comes from a time as close to the time the event occurred as possible. Using data generated years after the event is considered far from ideal. For example, historians prefer to use source materials that were created as close to the time of an event as possible. They only look at materials created several years later if those are the only available descriptions of an event. Yet that is exactly what scientometrics uses when evaluating a research project based on publications and citations. All this leads to the question: *What measure would allow for a better view of the actual research process?*

3.2.3 Early scholarly output

Fortunately, there are outputs that capture snapshots of how a research project develops and evolves. Most research projects have outputs prior to the publication of a formal, peer-reviewed article, including documents such as technical reports, newsletters, posters, invited talks, and research blogs (Cunningham, 1998; Trench, 2012). These types of non-peer-reviewed publications provide a way for researchers to get feedback on their research process. For example, in physics there are often links between an author's scientific blog entries and later arXiv pre-prints (Trench, 2012). Other research has found that Internet discussion groups are helpful when disseminating existing knowledge (Matzat, 2004). White papers and technical reports are often considered useful information sources, especially in industry and government settings (Wilkinson, Sud, & Thelwall, 2013).

This early output is often called 'grey literature' (Luzi, 2000; Luzi, Castriotta, Manco, & Mazzucco, 2006; Pappas & Williams, 2011). Grey literature has many definitions, but is generally considered to be documents, either print or digital, that are not controlled by commercial publishers (Ranger, 2005). In fact, government and industry technical reports are one of the most often cited types of grey literature in formal peer-reviewed publications (Alberani & Decastro Pietrangeli, 1995).

A few studies have attempted to determine the timeline or continuum of the publication of results, from informal to formal (Englander, 2013c; Swanepoel, 2011). Depending on the field, research often starts with a grant application and ends with a peer-reviewed journal article or conference paper, with intermediary outputs such as interim reports and conference posters in between those two bookends (Englander, 2013b). Researchers who receive funding from government agencies often produce a white paper or interim report prior to publication, through scholarly venues such as conferences or journals (Nathan, 2008). In humanities research, scholars typically first present at a conference, and then revise based on the feedback they receive before publishing a more polished version, most frequently as a journal article or book (Brown, 2002). Depending on the field, anywhere between 15% to 50% of research presented in these types of lightly reviewed venues ends up in formal, peer reviewed publications (Schunn et al., 2002; Thelwall & Kousha, 2008).

Currently, very few metrics even attempt to assess the early outputs of a research project. The prevalence of early research outputs combined with the lack of measure of this output leads

to the question: *What can we learn from seeing the entire scholarly output from the research process?*

3.2.4   Addressing the limitations of traditional measures

To address this, I constructed an arc of scholarly output that attempts to track the trajectory of a research project from the first stages of receiving informal feedback to the final stage of peer-reviewed publication. The goal of this arc is to represent the typical path from the start of a scholarly project to completion. That completion could include any number of final outputs, including peer-reviewed publication, prototypes, patents, or art exhibitions. Essentially, the Scholarly Arc seeks to represent how scholars get feedback on a project, from the first informal sharing of results to final publication for peer review and critique. Each step in the arc is intended to represent the work necessary to develop and refine an initial idea into a final product, whatever that product may be. In fields where peer-reviewed publication is the ultimate goal, the steps along the arc are often prior to peer-reviewed publication, such as posters, invited presentations, and workshops. In fields that value additional outcomes besides peer-reviewed publications, the steps could include other creative outputs designed to garner early feedback, such as YouTube videos or working prototypes.

This approach focuses on the process of research, rather than on the final outcomes of that research. Focusing on the process of research is advantageous in part because the progress of any project is driven by the creative process (Simonton, 2004). No matter what complex problem creative thinking is applied to, it usually involves many iterations of gathering more knowledge, generating new potential solutions, validating those solutions, and deciding on the next steps (Amabile, 1988). Getting feedback on ideas and the implementation of those ideas is often critical to overcoming challenges and arriving at a good solution (Hargadon & Sutton, 1997). The feedback scholars receive when presenting their work to various audiences serves the same function, and can be critical in shaping later versions of research dissemination (Garvey, Lin, Nelson, & Tomita, 1972c).

3.3   Methods of Constructing the Scholarly Arc

Constructing this Scholarly Arc consisted of three steps. First, I collected CVs from funded MCubed researchers. Second, I categorized the outcomes depicted on the collected CVs.

Third, I tracked research projects on a sample of CVs to validate the categories created in the second step.

3.3.1 Population of interest

The population of interest for this study was funded MCubed token holders, because funded MCubed projects would likely generate the same types of output that the collaborators on those projects had previously produced. To start, I initially compiled a list of over 650 researchers who were funded through MCubed. The goal was to understand the types of output each of these scholars typically produced.

Certain types of data were aggregated to the unit level for initial analyses. I selected this unit as an aggregation variable because individual schools and colleges usually establish clear guidelines regarding what types of outputs a particular unit recognizes when considering faculty for promotion. This means that a scholar will often constrain the types of output she generates to match those guidelines. By inference, outputs not generated by any member of a given unit are probably not recognized as valid by that unit. The units represented a critical aspect of the institutional environment surrounding the individual researchers funded through MCubed.

The funded MCubed projects were the unit of analysis for quantitative verification of the Scholarly Arc (described below), rather than individual token holders. If I had used token holders as the unit of analysis, each publication might be counted multiple times because all collaborators were included in the author list. By using projects as the unit of analysis, each output would be associated with a single project.

3.3.2 Data sources

One way to understand the range of research process outputs is to study researchers' CVs, which ideally provide a comprehensive list of their activities. Up to this point, CV studies have covered three topics: researcher career trajectories, researcher mobility, and researcher social and collaborative dynamics (Cañibano & Bozeman, 2009). A number of studies have used researcher CVs in this manner, often combining CV data with other data sources such as surveys and/or traditional bibliographic data (Cañibano & Bozeman, 2009; Dietz, Chompalov, Bozeman, Lane, & Park, 2000; Sandström, 2009; Woolley & Turpin, 2009; Youtie, Rogers, Heinze, Shapira, & Tang, 2013; Lepori & Probst, 2009).

Collecting data from a researcher's CV is advantageous in that it potentially provides detailed information regarding that researcher's career (Dietz et al., 2000). On the other hand, this detail can be overwhelming to code for analysis (Dietz et al., 2000). Most studies that use CVs as a data source will select data based on specific hypotheses (Cañibano & Bozeman, 2009; Dietz et al., 2000; Lepori & Probst, 2009; Sandström, 2009). In this case, I focused on the general types of research output listed in the CV, rather than the details of individual publications. Individual CVs were the sampling unit. CV headings and the individual items listed under those headings were the recording units for the process of constructing the Scholarly Arc. Overall, I gathered 656 CVs of researchers who were funded through MCubed. Of those, 41.5% (272) were full CVs, and the rest were truncated in some way (see Table 1). The process of collecting the CVs is detailed in the next section.

Only complete CVs were used to determine research output categories and tracking projects, because truncation would provide an incomplete picture. In departments where less than fifteen complete CVs were collected, all CVs for that department were selected for coding. In departments where there were more than fifteen complete CVs available, I chose to code between seven to fifteen CVs. In cases of large, diverse departments such as engineering or social science, I attempted to choose CVs for researchers with different specializations within that department. For example, in natural science, I used CVs from ecology and environmental science, physics, chemistry, and mathematics. In social science, I used CVs from sociology and organizational studies, women's studies, communication studies, and political science. This process resulted in 156 CVs that were used to develop the code definitions. This process is described in more detail in the next section.

In addition to funded token holder CVs, I used a combination of survey responses from MCubed project collaborators from both the MCubed evaluation and the MCubed administrative team. In particular, I used responses from a series of questions posed to funded token holders in the third MCubed Evaluation Survey. This survey was sent to all MCubed token holders and a matched control population. The questions used in this analysis were only presented to funded token holders, and asked whether the MCubed funded project had produced or would produce a specific type of output. These outputs were journal articles, conference presentations, patents, performances, and other research products (see Q84, Q113, Q124, Q263, Q89, Q90a, Q90b, and Q56 under MCubed Evaluation Faculty Survey 3 in the Technical Appendix). The third MCubed

Evaluation survey was deployed in October 2014. The response rate for funded token holders was 34.8%. (See the MCubed Evaluation technical appendix for further details.)

In addition to the MCubed evaluation surveys, Valerie Johnson from the MCubed administrative team gave me the results from the registration survey for the second MCubed Symposium, which took place on October 8–9, 2014. In this survey, funded token holders were asked to list a variety of outputs from their MCubed funded project; specifically, invention reports, publications, internal and external funding, and artistic and other products. Where the MCubed Evaluation Survey just asked if a project had produced a particular type of output, the MCubed Symposium Survey asked respondents to fill in a citation where possible.

3.3.3   Step 1: Collecting CVs

First, I used the list of funded MCubed token holders to create an Amazon Mechanical Turk (MTurk) task. The instructions told the MTurk workers (MTurkers) to click a pre-constructed Google search link for a professor in a specific university department. They were then asked to copy and paste the URL of the most complete list of publications and/or presentations. The best link was defined as (a) the link with the largest number and variety of publications, and (b) the most recently updated link. I also included an example of the most desirable outcome (i.e., a complete and up-to-date CV), and an example of a result that was acceptable but not preferred (i.e., a list of selected publications). I repeated this process in cases where the MTurkers did not find a complete CV.

As a result, I had one to five separate links to potential publication lists for the researchers in my sample. In most cases, I was able to determine the best CV for my purposes fairly easily based on these links. For example, the links provided by the MTurkers with file names similar to 'LastName_CV_year.pdf' were clearly relevant for my purposes. In other cases, all the MTurkers provided the same link to the same suboptimal but acceptable truncated publication list.

There were 68 researchers for whom the various MTurkers had submitted multiple links to publication, and it was not possible for me to quickly verify which link was best for my purposes. As a final step, I compiled the links to publication lists for those 68 researchers and asked MTurkers to rate which of three links was best on three criteria: most current, most

publications listed, and most variety in publications. This allowed me to more quickly determine which publication lists to use in later analysis.

3.3.4 Step 2: Analyzing and categorizing research outcomes listed on CVs

I used content analysis techniques to analyze individual CVs. Content analysis entails six steps: (1) define a context for analysis, (2) determine sampling units and recording units, (3) select a representative sample, (4) code the sample according to analytical constructs, (5) infer relationships between the coded data and the phenomena of interest, and (6) validate the results (Krippendorff, 1989).

The analytical constructs used in this study stemmed from a desire to understand how researchers disseminate the results of a research project. Some previous work in this area modeled this as an information flow starting with the initiation of work on a project and ending with final publication, with between ten and fifteen intermediate steps (Englander, 2013b; Garvey, Lin, Nelson, & Tomita, 1972c). Others have conceptualized this as a two-dimensional continuum with informal to formal along one axis, and analog to digital along the other axis (Swanepoel, 2011). These theoretical constructs formed the starting point for establishing the context of my CV analysis.

Once code categories were established, research outputs were placed in a content-analytic summary table with categories along the top, researcher names along the left side, and CV headings listed in the appropriate cell (Miles & Huberman, 1994).

I validated the category definitions using a second coder, who analyzed a set of complete CVs. Eight CVs were set aside for training the second coder. Category definitions were revised and refined as a result of the discussions in these training sessions. Once the second coder was comfortable with the category definitions, one complete CV was randomly selected from each department with at least two complete CVs that were not used in training sessions. CVs from departments with only one complete CV available after the training session were selected. A total of 22 CVs were used in the validation step. Krippendorff's Alpha for inter-coder reliability was calculated using SPSS (Hayes & Krippendorff, 2007). The resulting value was 0.786 with a 5.27% chance of being below 0.700, and a 95% confidence interval between 0.680 and 0.877. When reporting alpha values, 0.800 is generally considered good, and 0.670 is considered the minimum acceptable value. This places my results squarely in the acceptable range.

3.3.5 Step 3: Testing Scholarly Arc categories

The last step was to validate the arc of scholarly output against projects that could be identified within an individual's CV. To do this, I attempted to track the outputs of a single research stream, to see the evolution of a research project. Additionally, I determined what outputs were generated from the MCubed projects, and used those outputs to generate correlations between the Scholarly Arc categories defined in Step 2.

3.3.5.1 *Qualitative verification: Tracking the evolution of research projects*

First, I choose one to five CVs in each department listed above. In choosing these CVs, I tried to find project titles that did not have an excessive amount of technical jargon. For example, in medicine I chose to study a researcher who studied how psychosocial factors affected cardiac rehabilitation. In another case, I looked at a researcher in the pharmacy department whose research focused on breast cancer.

I then searched the CV for keywords related to that topic, which generally resulted in between two to fifty results. Keyword search results with only a few items were discarded, because one or two items were not enough to show a progression. For the purposes of this verification step, I defined a research theme as a line of research that was revisited multiple times over the course of a researcher's career. Keywords that returned forty or fifty results were discarded because that indicated an overarching research theme rather than a specific project, especially when the results of that search spanned time frames of more than five years. Each research theme could be made up of multiple research projects. Each project might look at specific instances or aspects of the phenomena that make up an overall research theme. Ideally, I looked for keywords that returned between seven to fifteen results and spanned a limited time frame.

A second criterion was to find CVs that included grey literature, as well as titles and dates for those items. For example, there were a few CVs where a scholar listed the date and venue of a talk, but not the title of that talk. When choosing projects within a CV, I tried to find projects that were listed under more headings than just formal peer-reviewed publications, and ideally encompassed at least three of the four project-specific categories (peer-reviewed publications, lightly-reviewed, non-peer-reviewed, and informal). A scholar who only listed a few local seminars limited the project keywords I could use for verification. If the CV listed all

peer-reviewed publications but only recent invited talks, I chose topics that were included in the recent invited talks.

Finding research themes through keywords in titles is certainly not perfect. I am sure I missed key items, especially in cases where I only found two or three titles that matched my keyword search. Nevertheless, I was able to find enough coherent projects in each department to give an overall picture of the general progress of a research project. Overall, I tracked 93 projects from 45 separate researchers.

3.3.5.2 *Quantitative Verification: Correlations of Scholarly Arc categories*

I decided to follow the qualitative verification of the Scholarly Arc with a quantitative analysis based on the projects funded by the MCubed initiative. The first step in this process was to determine which projects had produced output, and categorize that output using the definitions generated in step two.

If respondents indicated that a journal article had already been published, the project was marked as having peer-reviewed output. If the respondent marked that a journal article was planned or that a journal article was not planned, the project was marked as not having peer-reviewed output. Patents followed this same decision strategy but were classified as lightly-reviewed output.

If respondents indicated that they had already presented at a conference, I looked at the respondent's field. If a recent CV (2013–2015) for that person was available, I consulted the CV to verify whether the conference was listed as a peer-reviewed publication. If I found a conference paper matching the MCubed project title and description on a CV, or if the respondent was from computer science or another field where the conference venues were peer-reviewed, the project was marked as having a peer-reviewed publication. Otherwise, the project was marked as having lightly reviewed output. Again, if no conference presentation was planned or if one was planned but not yet completed, the project was marked as not having lightly reviewed output.

I repeated this process for posters and other research products such as website archives or software. If a CV indicated that the poster was presented at a national or international conference, the project was marked as having lightly-reviewed output. Otherwise, the project was marked as having non-reviewed output.

My last data source for project outputs was funded token holder CVs. If a project scored zero or had missing data in the peer-reviewed, lightly-reviewed, or non-reviewed output categories, I looked up the most recent CVs available for that project's collaborators. If the CV listed publications from 2013 or later, I scanned the relevant portions of the CVs during the time periods from 2013 onward to determine if any publications matched the titles or descriptions of the MCubed project. I erred on the cautious side. If a CV contained a large number of items that matched keywords in the project title or description, I judged that these items reflected the output from a general research theme rather than a specific research project. I marked project outputs only if the item listed on the CV closely matched the MCubed project title and description. This conservative approach probably resulted in missing some relevant project outputs.

3.4   Results: Constructing and Validating the Scholarly Arc

My goal was to form an arc of scholarly output that included all outputs of a research project rather than just the final, polished output. This could then become a measure of near-term research output rather than the long-term research output typical of traditional measures such as publication and citation counts, rendering the arc of scholarly output valuable as a temporally proximate measure of research productivity. I would then be able to more clearly see the false leads encountered by researchers along the way, and how those researchers were able to turn those problems into a solid discovery.

3.4.1   Results of Step 1: Collecting CVs

I gathered 656 CVs through Amazon Mechanical Turk, 41.5% (272) full CVs and the rest truncated in some way (see Table 3-1). The truncated CVs were usually a) limited to items listed to peer-reviewed publications, and b) limited to items listed to a recent period of time. In any given CV, one or both of these limitations could be found.

Department	Complete CVs	TRUNCATED CVs	Total CVs
Medicine	25 (14%)	154 (86%)	179
Engineering	42 (30%)	98 (70%)	140
LSA: Natural Science	30 (41%)	44 (59%)	74
Public Health	40 (85%)	7 (9%)	47
LSA: Social Science	19 (58%)	14 (42%)	33
Dentistry	5 (21%)	19 (79%)	24

School of Natural Resources	19 (90%)	2 (10%)	21
Information	18 (86%)	3 (14%)	21
LSA: Humanities	12 (75%)	4 (25%)	16
Pharmacy	11 (69%)	5 (31%)	16
Life Sciences Institute	1 (7%)	13 (93%)	14
Architecture & Urban Planning	9 (100%)	0 (0%)	9
Business	9 (90%)	1 (10%)	10
OVPR	2 (20%)	8 (80%)	10
Kinesiology	8 (100%)	0 (0%)	8
Institute for Social Research	6 (75%)	2 (25%)	7
Nursing	2 (33%)	4 (66%)	6
Education	2 (40%)	3 (60%)	5
Libraries	2 (50%)	2 (50%)	4
Art & Design	3 (100%)	0 (0%)	3
Music Theatre & Dance	2 (100%)	0 (0%)	2
Public Policy	1 (50%)	1 (50%)	2
Law	1 (50%)	1 (50%)	2
Graham Sustainability Institute	1 (100%)	0 (0%)	1
Social Work	0 (0%)	1 (100%)	1
Total CVs	272 (41.5%)	383 (58.4%)	656

Table 0-1: Comparison of complete vs. truncated CVs by university department

The first form of truncation limited the listed items on the CV to peer-reviewed publications such as journal articles or book chapters. This type of truncation was more common in some departments than in others. The main driver in this type of truncation was the department's use of a university website (experts.umich.edu) that automatically populated scholar profiles with results from the Scopus database. Scholars in Engineering and Medicine were most likely to employ this type of CV truncation. These were also the largest departments in the university, and the two units contributed the most to the dearth of full CVs. Other departments encouraged scholars to make their full CVs available. These departments included the School of Information and the School of Architecture.

The second form of truncation limited items to a given period of time, or most significant publications, rather than the scholar's entire career. This type of CV truncation occurred when departments provided a web space for scholars to list their publication, but where scholars were required to manually enter the publication lists. Senior scholars were also more likely to use this

type of CV truncation. In this case, some scholars listed all peer-reviewed publications, but only listed presentations or other grey literature going back between five and fifteen years. For example, one scholar only listed seminars back to 2000. This type of truncation had little impact on the construction of the Scholarly Arc, because the main criteria for that step was the comprehensiveness of the listed items, rather than when those items were produced.

3.4.2 Results of Step 2: Categorizing Research Outcomes

Initial Scholarly Arc category definitions were based on a variety of criteria, including prior research, previous publication rules for archival venues in various fields, and tenure materials for university departments (Brown, 2002; Garvey, Lin, Nelson, & Tomita, 1972c; Nathan, 2008; Schunn et al., 2002; Thelwall & Kousha, 2008; Zhang & Glänzel, 2012). These category definitions gave me a clear idea of the criteria for each field's definition of a final, peer-reviewed publication. Table 3-2 summarizes the prior publication policies of some common publication venues in a variety of fields.

For example, one publisher specifically stated that it is common for technical papers to start as workshop papers with a later presentation at conferences before final publication in journals. Additionally, some major journals (e.g., *PLOS One*, *Nature*, and *Blood*), in their description of the qualifications for prior publication, specifically mention online posting of preliminary results. While some are generally willing to accept previous work that has been informally published online, others have strict policies limiting such works.

Field	Publisher	Accepts preliminary data/findings previously published		
		Online	Workshops/Conferences/ Profession meetings	Other Early Publication Venues
General (includes Social Science, Humanities & Arts)	Wiley	Data repositories	Abstracts, posters, presentations	
	Elsevier		Abstracts, posters, presentations	
	Sage	Consult the editor		
General Science	Science		Presentations	
	Nature	Blogs,	Abstracts, posters,	

		wikis, pre-print archives	presentations	
	PLOS One	Blogs, wikis, tweets, pre-print archives, data repositories	Abstracts, posters, presentations	
Technical/ Engineering	ACM		Non-archival/ no formal review publications	Technical reports
	IEEE		Posters, presentations	
Medicine	Oxford journals	As long as not a "finished product"	Presentations, posters	Working papers disseminated to a limited audience
	New England Journal of Medicine		Presentations, posters	Submissions to government oversight boards
	Blood	Brief abstract	Presentations, posters as long as NOT archived online	
Law/Public Policy	Barry University School of Law			Working papers
	New England Journal of Public Policy			Working papers

Table 0-2: Preliminary analysis of early publication venues by field

The next step was to take these initial category definitions and refine them, based on the items listed in the sampled CVs. The result was five simplified categories: formally peer-reviewed, lightly peer-reviewed, non-peer-reviewed, informal, and orthogonal. The description of each of these categories below gives the general definition, and notes regarding what typically falls into each step. See Table 3 for examples of what types of items fall into each category described below.

3.4.2.1   *Peer-reviewed publications*

Generally, a research output qualified as formally peer-reviewed if others who were knowledgeable in the domain of the scholarly project recognized it as a scholarly contribution. These research outputs are the final outputs of scholarly work studied carefully by academic peers and accepted for publication, often after requesting revisions. A manuscript significant

enough so that it could not be republished in another venue represented the final output of a scholarly project.

Not surprisingly, many fields differ in their definition of a peer-reviewed venue. In the case of fields where written works are not necessarily the typical output (e.g., Art, Architecture, Music, and Theatre), any item listed in a tenure case belonged in this category; the reasoning being that peer-reviewed publications are normally considered for tenure in most fields. Where fields that do not necessarily produce peer-reviewed publications view a specific type of output as tenure-worthy, that output is roughly equivalent to a peer-reviewed publication.

In some fields—most notably computer science and related fields—many conference papers are heavily peer-reviewed and in archival publications. Thus, they are considered equivalent to journals in terms of scientific contribution. In other fields, the items presented at a conference most suitable for extending into an article (about 30%–50%) are often published later in archival compilations of the conference proceedings (lez-Albo & Bordons, 2011; Zhang & Glänzel, 2012). These extended conference submissions go through two rounds of peer review: when accepted for the conference, and when the conference submissions are extended into journal-length articles (lez-Albo & Bordons, 2011; Zhang & Glänzel, 2012).

3.4.2.2 *Lightly Peer-reviewed publications*

Written documents falling somewhere between non-peer-reviewed and formally peer-reviewed were defined as "lightly-reviewed." Generally, items in this category were written documents but not archival publications, although at least one or two people with expertise in the field had looked over a written description of the scholarly work, and decided it was academically interesting, worthwhile, promising, or otherwise valid. The work had to be sufficiently interesting or promising, but that bar was not nearly as high as the bar for formally peer-reviewed works. Most lightly peer-reviewed conferences were larger venues that attracted attendees from across large geographic areas, such as national or international conferences that did not archive the papers presented at the conference. These items were generally not published in proceedings (Zhang & Glänzel, 2012).

3.4.2.3 *Non-Peer- reviewed written material*

Items in this category were generally early written drafts describing the scholarly process and outcomes that may eventually have become lightly-reviewed or fully peer-reviewed. This

category also contained written materials based on the scholarly project, but intended for non-academic audiences such as commercial or governmental organizations. This category also included items that were edited but not reviewed by academic peers. Items created in the process of completing a specific research project—such as software or prototypes—were also assigned to this category.

3.4.2.4 Informal

Items in the informal category were mostly spoken communications such as invited presentations, panel discussions, and seminars. There were two reasons for this. First, it is easier for people to talk extemporaneously without editing their words. Presentations tend to be more rehearsed, but there is opportunity for improvisation either in the middle of the presentation or during question-and-answer sessions after the presentation. Unlike the written format, these impromptu sections are typically not closely edited. Second, items in the informal category are less likely to be archived for later retrieval. Sometimes these sessions are recorded, but those recordings are less likely to be part of a permanent, publicly available archive. This improvisational quality applies across all fields, such as music or other performances. Presentations to smaller audiences, such as groups local to a university or school, would fall into this category.

3.4.2.5 Orthogonal

Orthogonal items were not direct outcomes of a specific scholarly project, but were related to a scholar's perceived expertise or domain knowledge in a field of study. The scholar's overall research agenda or experience informed the contents of these items, rather than the outcome of a specific project. Most often, these items were requested from the scholar based on someone else's recognition of that person as an expert in a specific area. Sometimes a scholar may have produced some items on their own initiative, based on a perceived lack of informational material regarding a certain topic. This category was not intended for analytical purposes. The idea behind this category was to provide clarity when providing the coding definitions to others.

Written and/or recorded output of a research project	Non-recorded output of a research project	Non-project-related materials

Peer-Reviewed	Lightly Peer-Reviewed	Non-Peer-Reviewed	Informal	Orthogonal
Journal articles	Published abstracts	Policy/ technical reports & notes	Invited talks, presentations, or lectures	Reviews
Books	Non-archived conference posters and presentations	White papers	Seminars	Commentary, editorials, or letters
Book Chapters	Working papers in edited publications	Technology disclosures	Colloquia or Symposia	Newsletters
Papers in archival conference proceedings	Patents	Working papers	Panels	Press releases or news reports
Refereed archaeological field reports	Articles in trade/ professional publications	Educational materials	Unscripted performances	Government or court testimonies
Peer-reviewed data sets	Minor planets electronic circulars	Commissioned position papers or other work		Exhibition curator
Exhibitions (solo & group)	Archaeological fieldwork	Workshop papers		Discussant
Published design, art, literary work, or music	Work in public collections or public art installations	Software		
Complex or large audio-visual compositions and performances		Personally published data sets		
Major building projects		Briefs		
		Entrepreneurial activity		
		Work in private collections		
		Translations		

Table 0-3: Examples of items in each step of the Scholarly Arc found on CVs in analysis

3.4.2.6 *Intercoder differences in assigning Scholarly Arc categories*

There were a variety of reasons for differences between coders' definitions of what item fell into which category. Many researchers lumped multiple types of outputs under a single "Other publications" category. For example, it was common to find encyclopedia articles, book reviews, and other types of publications lumped together. In these cases, coders often made

different decisions about how many individual items under those headings were coded. Another reason for inter-coder differences was a varying level of knowledge of other fields. For example, someone unfamiliar with solar-system-based astronomy would not necessarily know what "minor planets electronic circulars" were, much less how they should be coded. Other items were difficult to code because the topic discussed within the item could not be inferred from the title. "Testimony" is an example of one of these items. The topic of the testimony could be based on the results of a single research project, or the scholar's position as an expert in a particular domain. This would be difficult to determine without reading the transcripts of the testimony, and something that could vary by field.

3.4.3   Results of Step 3: Testing Scholarly Arc categories

3.4.3.1   Tracking the evolution of research projects

The first step in verifying Scholarly Arc categories involved tracking the outputs of a single research stream, to see the evolution of a research project. Some research projects were quite easy to track because they all used similar titles. For example, one social science researcher studied adolescent body image. Within that research theme, five titles began with the phrase "Virtually perfect": three departmental invited talks in 2009, one international conference in 2011, and finally a journal article in 2014. Due to the relatively small number of items with this title, and the limited time frame, I interpreted this as a single research project.

I was able to track other projects by looking at recurring keywords that indicated a constrained research project. For example, one researcher from the Computer Science department within the College of Engineering was generally interested in collaborative visualizations. Various research projects within this overarching research theme were distinguished by specific events or places. One of those research projects focused on post-disaster visualizations of buildings and infrastructure. In this case, I searched the researcher's CV for titles containing the word "disaster." This search resulted in two refereed conference papers in 2005 and 2006, three invited presentations in 2007, a non-refereed conference paper in 2009, and finally a journal article in 2011. While the time between first and last dissemination of results spanned more than five years, the relatively small number of outputs listed indicated that this was one project within a larger research theme.

Generally, the output of a scholarly project listed on a CV for a given project often alternated between informal talks at seminars, non-peer reviewed written documents, and lightly-reviewed documents, before it was finally published in a full peer-reviewed venue. This pattern of jumping back and forth between informal and formal venues held true in all of the fields tested. For example, the above mentioned engineering project on post-disaster visualizations started with two peer-reviewed publications. It then went from lightly-reviewed, to informal, to non-reviewed, before being published in a peer-reviewed journal. An earlier project on women's sports media by the social science researcher described earlier moved back and forth between the different categories. It started with a lightly-reviewed conference presentation, followed by one invited colloquium, three more conference presentations, one non-peer-reviewed public commentary, three more invited colloquia, another conference presentation, and finally a journal article.

Alternatively, there are projects whose only outputs were informal, non-peer-reviewed, or lightly-reviewed, which could mean a couple of things. First, not all projects turn into peer-reviewed journal articles. Second, the scholar was in the process of generating a formal peer-reviewed publication. For example, if a scholar lists invited talks and conference presentations for 2013 or 2014, but does not list any journal articles, it may have meant that the project was still in the early stages of the research process.

The non-peer-reviewed category was more likely to be skipped than the other categories, which could be a limitation in the definition of the category. Alternatively, scholars may not typically put non-reviewed written materials on their CVs. The caveat is that I did not use working papers or works in progress when verifying the arc, because these materials do not usually have dates, which limits their use as a verification tool.

This back and forth between informal, no review, and lightly reviewed was typical across most projects, perhaps because researchers will be invited to give informal talks at other universities after presenting their research at a conference. Alternatively, someone may prepare for a conference by giving practice presentations to different departmental groups at their home university.

In other researcher projects, peer-reviewed publications tended to be published in loose groups. In some cases during the review cycle, multiple papers happened to get to the point of acceptance in the publication cycle at the same time. In other cases, the publications could have

been purposefully published at the same time. One researcher had a series of five publications in 2005: one journal article and five refereed conferences. Four of these publications were on sparse approximations. Two of the publications focused on algorithms for sparse approximation, and two were more application-focused.

Other projects tended to be published in cycles. For example, one research project studied the interaction between atmospheric nitrogen and terrestrial ecosystems. In this case, peer reviewed publications, such as book chapters or journal articles, were often published in cycles. The first journal article on nitrogen deposition was published in 1999. Two more peer-reviewed papers were published in 2000 and 2001. Seven years later, a book chapter on deposition was published. The next publication title that included nitrogen deposition was in 2011, indicating an extended research theme. Using this description of a research theme, this researcher had a number of inter-related research themes.

Occasionally, researchers gave a series of informal presentations after publishing in a peer-reviewed venue. In these cases it appeared that the researcher was giving a job talk, or giving talks to prepare for a tenure case. For example, one researcher in Dentistry published a journal article in the same year he defended his PhD thesis. Three years later, he gave a series of informal talks on the same topic at the university where he was an Assistant Professor at the time. Six months later, he gave talks with the same title in four different universities. These talks all occurred during the time he would have been putting together a tenure case for Associate Professor, which he achieved.

3.4.3.2 *Quantitative verification of Scholarly Arc*

While the qualitative verification of the Scholarly Arc gave me a detailed view of the evolution of a variety of research projects, I decided to supplement those results with a quantitative verification step. I ran Pearson's correlations on the output from funded MCubed projects where complete output data was available. There were 90 projects with data for all four types of output. There were 23 projects that had produced every type of output, and one that had only peer reviewed output. Table 3-4 shows the results of a Pearson's correlation between the different types of project output.

	Lightly reviewed output	Non-reviewed	Informal

	output	output	
Peer reviewed output	.456***	.006	.153
Lightly reviewed output		.092	.363***
Non-reviewed output			.146

Table 0-4: Pearson correlations between different types of output in MCubed projects (N=90). *** p < .001

As Table 3-4 shows, peer-reviewed and lightly reviewed output had the highest correlation in the positive direction. Non-reviewed output had very low correlation values with every other category and was not significant in any of them, indicating that the definition of this category might require some refinement. As an initial step in this direction, I combined the informal and non-reviewed output categories. For the sake of direct comparison, I ran a new set of correlations on the same set of data as the previous set, as shown in Table 3-5.

	Lightly reviewed output	**Informal/ non-reviewed output**
Peer reviewed output	.451***	.290**
Lightly reviewed output		.657***

Table 0-5: Correlations between different types of output in MCubed projects (N=90). ** p < .01; *** p < .001

Combining the non-reviewed and informal output categories increased the positive correlation between lightly reviewed output and informal/non-reviewed output. This correlation was significant at the p < .001 level. It did not, however, significantly increase the magnitude of the correlation between peer-reviewed output and informal/non-reviewed output, although the level of correlation became statistically significant at the p < .01 level.

3.5   Discussion

I constructed an arc of scholarly output based on the results of defining categories and verifying that the categories served to track the progress of a research project. This arc served to track the trajectory of a research project from the first stages of receiving informal feedback to the final stage of peer-reviewed publication or other field-based goals. The goal of this arc was to create a temporally proximate measure of the research process, mapping the path from the start

of a scholarly project—whether research or otherwise—to completion. This map also has the potential to provide a much finer-grained look at the evolution of a project, with all the stops and starts that result from false leads and setbacks. Moreover, the Scholarly Arc includes a much wider range of final outputs than that included in traditional measures such as publication or citation counts. While the Scholarly Arc cannot capture every type of output generated by every scholarly project, it does create a mechanism for comparing the majority of scholarly project output.

Essentially, the Scholarly Arc represents how scholars get feedback across a project's life cycle. Each step in the arc represents the effort necessary to develop and refine an initial idea into a final product. In fields where peer-reviewed publication is the ultimate goal, the steps along the arc—such as posters, invited presentations, and workshops—are often prior to peer-reviewed publication, In fields that value outcomes other than peer-reviewed publications, the final steps could include other creative outputs, such as major building projects.

The strength of this approach is that it focuses on the process of research, rather than the final outcomes of that research. Focusing on the process of research is advantageous because the progress of that project is driven by the creative process, regardless of the project's field (Simonton, 2004). The complex problems of creative thinking usually involve many iterations of gathering more knowledge, generating new potential solutions, validating those solutions, and deciding on the next steps (Amabile, 1988). Getting feedback on ideas and the implementation of those ideas is often critical to overcoming challenges and arriving at a good solution (Hargadon & Sutton, 1997). The feedback scholars receive when presenting their work to various audiences serves this same function, and can be critical in shaping later versions of research dissemination (Garvey, Lin, Nelson, & Tomita, 1972c).

3.5.1 The Effect of Truncating CVs

In the process of constructing the Scholarly Arc I encountered the issue of truncated CVs. The truncation of CVs to "recent publications" is common in CVs publicly available on the web (Dietz et al., 2000; Lepori & Probst, 2009; Sandström, 2009). While previous studies have discussed the methodological implications of CV truncation, few have discussed how that truncation influences the perception of a researcher's impact.

Whether or not research outputs are formally peer reviewed, early efforts to get feedback on a project by presenting the results in large and small venues serve to increase the impact and visibility of a line of research. By the time the research is published in peer-reviewed venues, the information is often considered out of date, because the results have already been disseminated through presentations at seminars, workshops, or conferences (Garvey, Lin, & Tomita, 1972b; 1972a). Ignoring these venues when considering the validity of research output discards critical information.

Additionally, ignoring these pre-publication venues hides the impact of the university and the department within the university. Universities are not just known for their publications. The activities of faculty at conferences and within a community of practice serves to heighten awareness of the university as well as the faculty member's home department. University public affairs offices are well aware of the advantages of promoting individual faculty as the intellectual capital of the university (Kahlon et al., 2014).

With less funding for research, and increased Congressional oversight of the distribution of those funds, researchers must compete for scarce funds. Imagine that a research project which creates educational materials for children about healthy habits is under scrutiny for its effectiveness. Now imagine the report written by a Congressional intern browsing the public websites of those running that research project. If only peer-reviewed publications are visible on public CVs, the impression is of an academic who never leaves her ivory tower. Now contrast that image with someone who lists all the outputs of her project, including the online educational materials and the community outreach performed in the course of completing the project. The overall impression is very different.

Realistically, most research projects won't come under Congressional scrutiny. But people and organizations outside the academic field of a researcher may still pay attention to that scholar's research. Therefore, a measure that takes the wider impact of a research project into account becomes more important, because it draws attention to research activities and outcomes that make a university stand out in the larger community, both geographically and academically.

3.6   Conclusion

I constructed an arc of scholarly output based on defining categories and verifying that the categories served to track the progress of a research project. This measure is much more

temporally proximate to the actual research process, and thereby provides greater insight into that process. This approach broadens the focus from a single research output to all the steps along the way. A peer-reviewed publication is not the intended result of every project, and this measure helps to remove the current bias in scientometrics toward research whose main goal is a peer-reviewed publication. I verified the items composing the arc through inter-coder reliability and by verifying research projects found in the CVs used to construct the arc. I will discuss the limitations and future work related to this study in Chapter 5.

In developing the definitions for each level of the Scholarly Arc, it became quite clear that the type of scholarly output supported and rewarded in one university unit was completely unrecognized in another. This difficulty applies to the intersection of two questions in Chapter 1: whether the institutional environment supports interdisciplinary research, and whether interdisciplinary research is beneficial. If a researcher's department does not recognize a particular type of research output, there is little or no incentive to produce that output. Therefore, whether interdisciplinary collaboration provides concrete benefits depends on what type of output is valued by a researcher's institutional environment, which in turn guides whether the effort to produce that type of output is supported.

As mentioned in the introduction to this chapter, I needed a more temporally proximate measure of research output than provided by traditional measures of research output. The Scholarly Arc fills this need by including early research outputs to the measurement of research output. Constructing the Scholarly Arc was a critical step that enabled the analysis I present in the next chapter. Chapter 4 uses the output of the funded MCubed projects generated for the quantitative verification of the Scholarly Arc as the dependent variables in a series of logistic regressions. Through the Scholarly Arc, projects that have produced results but that have not had sufficient time to produce peer-reviewed output will be included in the analysis as something other than simply failing to produce a peer-reviewed publication. This will allow me to understand what factors influence early progress on a research project, rather than just the factors influencing peer-reviewed publications. Using the Scholarly Arc categories in the next chapter allows me to verify that the categories defined in this paper work as a measure of research output as a whole. If there is output from a research project at an earlier step, the analysis will examine whether getting feedback through earlier steps makes it more likely for researchers to achieve

later steps in the Scholarly Arc. The details of this analysis are the main focus of the next chapter.

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Chapter 4
Analyzing Output From Funded Mcubed Projects

4.1   Introduction

This chapter addresses multiple research questions posed in Chapter 1. The goal was to determine how the following factors affected the output of a research project: (a) prior experience working together on funded research projects, (b) the support of the institutional environment, and (c) the degree of interdisciplinarity. I found that disciplinary similarity, not diversity, was positively correlated to peer-reviewed output. Similar levels of institutional financial support from collaborators in the various units were also positively correlated to peer-reviewed output. The most surprising result was that prior experience working together on a funded research project was negatively correlated to peer-reviewed output.

The key question raised in Chapter 1 is whether interdisciplinary collaboration has important benefits. Previous research suggests that while such benefits are possible, there are many pitfalls along the way. The first pitfall is whether the larger institutional environment surrounding a project supports researchers who are attempting to reach across disciplinary boundaries. Prior experience working together on funded research projects often makes the collaborative process smoother, because collaborators already know how to effectively work together.

Many researchers have argued that diverse teams produce more creative and innovative results. Diverse people bring different perspectives, heuristics, interpretations, and predictive models that can combine in new ways for a better solution than could any individual person (Page, 2007a; 2007b). Teams can bounce ideas off each other, refining those ideas as others

point out problems and weaknesses, in a process called distributed reasoning. Productive conversations and constructive criticism stimulate divergent, convergent, and creative thinking, which provides more space for creative exploration (Farooq, Carroll, & Canoe, 2008; Finke, 1996). When the conditions are right these factors can result in radical breakthroughs, because each person is representing the problem in a different way due to differences in individual backgrounds that are related, but not necessarily similar (Dunbar, 2000; Uzzi & Spiro, 2005).

While diversity can be very beneficial, diversity does not produce better outcomes in all cases (Page, 2007a) because the number of potential solutions, combined with widely divergent preferences for deciding which solution is ideal, can result in worse outcomes (Page, 2007b). Also, team diversity along multiple dimensions can affect a project negatively if all of the differences interact to adversely impact the same people. A variety of studies have found that gender and ethnic diversity can have a small negative impact on team performance, particularly when creativity and innovation are an important aspect of performance (Bell, Villado, Lukasik, Belau, & Briggs, 2011). The key to reaping the benefits of diversity and mitigating the negative effects is to actively engage in open communication, coordination, and similar social processes (Reiter-Palmon, Wigert, & de Vreede, 2011)

In this chapter, I will explore the effect that diversity has on creative output. First, I examine the various aspects of group composition, particularly those related to diversity, and how they affect the creative output of a group. Next, I use the Scholarly Arc described in Chapter 3 to understand how the composition of funded MCubed collaborations affects the creative output that emerges from MCubed projects. I end the chapter with a discussion of the results of those models.

4.2   Group Composition

Group composition is a key mediator variable when it comes to team performance (Reiter-Palmon et al., 2011). The most readily apparent aspect of group composition is demographic diversity, but demographic diversity tends to have less effect over time as people get to know each other (Bell et al., 2011). On the other hand, previous studies have shown that functional and educational diversity is positively correlated to innovation, although there is some difference of opinion on this point (Reiter-Palmon et al., 2011).

4.2.1 Gender

A recent trend shows an increasing number of women in interdisciplinary fields (Rhoten & Pfirman, 2007; van Rijnsoever & Hessels, 2011), perhaps because women tend to prefer "problem-based" fields, which are inherently more interdisciplinary (Rhoten & Pfirman, 2007). Other research suggests that a gender imbalance in research teams can negatively impact creative output (Bell et al., 2011), which may explain why women are more likely to collaborate with other women (Bozeman & Corley, 2004; Rhoten & Pfirman, 2007). In any case, the mix of men and women on an MCubed team should be a control variable in any analysis of MCubed project outcomes.

4.2.2 Ethnicity

Recent research has found that people of the same ethnicity are more likely to collaborate on published papers (Freeman & Huang, 2014). This suggests a higher number of homogenous ethnic teams in MCubed projects. The same report found that ethnic homophily also resulted in publication in lower-impact journals (Freeman & Huang, 2014). This conflicts with the theory that an imbalance in ethnicity in interdisciplinary collaborations can negatively impact creative output, especially if it interacts with other aspects of diversity (Bell et al., 2011). This conflict in the theoretical influence of ethnic diversity on MCubed collaborations means that ethnicity should also be a control variable in the analysis of Mcubed outcomes.

4.2.3 Rank/tenure status

Researchers who share certain characteristics, such as age and education, are not only more likely to collaborate, but those collaborations are more likely to produce innovative results (Cummings & Kiesler, 2008; Phelps, Heidl, & Wadhwa, 2012). Additionally, the depth of an individual's personal knowledge, and the knowledge available in their personal network, tends to increase innovation (Phelps et al., 2012). In a university setting, these factors are tied to an individual's rank. The longer someone has been in a community of practice, the more connections they have. Therefore, academic rank is a reasonable proxy for this concept.

Where a researcher is on the tenure track can also influence what comes out of a research project. Intense time-pressure negatively impacts an individual's creativity, especially when someone must regularly shift their attention from one task to another (Hennessey & Amabile, 2010). This time pressure can be particularly intense for researchers who are still in the process

of establishing themselves in their careers—for example, those working to achieve tenure. This suggests that an increased proportion of tenured faculty members in a project will be associated with increased creative output, and should be included as a control variable (Cummings & Kiesler, 2008; Phelps et al., 2012).

4.2.4 Institutional environment

The MCubed founders assumed that the differences in support for interdisciplinary collaboration in different university departments would be relatively small. Their hope was that the positive effect of disciplinary diversity on innovation would trump any variation in departmental support for interdisciplinary collaboration, following the idea that the individual and group are more important for creative output than the larger organization (Gaggioli, Riva, Milani, & Mazzoni, 2013; Woodman, Sawyer, & Griffin, 1993). If the MCubed assumptions are correct, the differences in support for interdisciplinary collaboration by the various units will not be a factor in project outcomes.

Institutional environment null hypothesis: The support for interdisciplinary collaboration within the departments of the collaborators will not affect the creative output of the collaboration.

In contrast, some studies suggest that research collaborations are shaped by the institutional structures surrounding them (Evans & Foster, 2011; Knorr-Cetina, 1982). In these studies, the organizations surrounding individual collaborators are critical in determining how creative and innovative an individual or group is (Amabile, Conti, Coon, Lazenby, & Herron, 1996). The institutional or organizational environment can impact the creative output of teams in many ways, such as valuing innovation by encouraging risk taking (Amabile et al., 1996).

The institutional environment surrounding a researcher starts with her immediate department, particularly the leadership and the people working in that department. This is because researchers look to influential people in their university and department for normative cues regarding research practices (Haas & Park, 2010). First, departmental colleagues have a strong effect on an individual's attitude toward interdisciplinary collaboration. Second, researchers often adapt their research questions and approaches to match the research orientation

of their department head, in order to increase their value (Knorr-Cetina, 1982). If the departmental leadership supports risky but innovative work, the people in the department will follow suit (Amabile, 1996).

An important aspect of the institutional and organizational environment includes the organizational norms and attitudes toward innovation and risk that shapes the behavior of an organization's members (Hargadon & Sutton, 1997). The attitudes of a researcher's department and colleagues toward collaboration and knowledge-sharing impacts the likelihood of a researcher embracing those paths (Evans & Foster, 2011; Figg et al., 2006; Haas & Park, 2010; Knorr-Cetina, 1982). If those peers model and encourage collaboration and knowledge exchange, individual researchers will follow suit (Haas & Park, 2010). By the same token, if collaboration and cooperation across disciplinary and departmental divides is encouraged, that organization's members will work to follow and live up to those norms (Sutton & Hargadon, 1996).

The institutional environment can impact research collaborations in negative ways as well. While the assumption of departmental support for collaboration is a safe one to make in certain fields such as nano-science or high-energy physics, it is not nearly as common in fields such as neuroscience and the humanities (Birnholtz, 2007; Jansen, Görtz, & Heidler, 2009). A researcher who perceives that her departmental leadership or colleagues do not support the type of work her group is undertaking will negatively impact the work of that group (Hennessey & Amabile, 2010).

Interdisciplinary collaboration often crosses organizational boundaries. By design, this is the case with the research projects funded through MCubed: the departments involved in a project will likely differ—potentially significantly—in the degree of support for interdisciplinary collaboration. Some departments may support the idea of interdisciplinary collaboration but do not have the resources to offer more tangible support. These differences originate at a larger institutional level, usually in terms of the funding available to scholars and their immediate organizations in a given field. The question is how the difference in institutional support affects project outcomes.

Theoretically, projects where all collaborators are from departments with both tangible resources and high levels of support for interdisciplinary collaboration will not have additional institutional barriers to producing results. In contrast, projects where all collaborators are from departments with either few tangible resources or support for interdisciplinary collaboration will

certainly face extra institutional barriers to producing results. Theoretically, these collaborators will overcome their lack of resources, because they have had to overcome the same barriers in previous research projects. Those projects most likely to face difficulty are those where some collaborators are from departments with plenty of resources, but where other collaborators are from departments with fewer resources. Collaborators from departments with more available resources may not understand the issues faced by collaborators from low-resource departments, or they may not be able to offer advice about how to overcome those issues. This leads to my first hypothesis.

> Institutional environment hypothesis: Smaller differences in tangible support for interdisciplinary collaboration within researchers' departments will be associated with increased creative output.

4.2.5 Disciplinary diversity

In the experience of the MCubed founders, combining the point of view of multiple disciplines resulted in more successful and innovative projects. This is a fairly common assumption that has some research to support it, particularly when performance is related to creativity or innovation (Bell et al., 2011). For example, some research shows that teams whose members span a wider range of disciplines are more innovative (Hargadon & Sutton, 1997; Page, 2007b; Uzzi & Spiro, 2005). If these assumptions are correct, greater diversity in fields will lead to more successful projects. This will form the null hypothesis for functional diversity.

> Disciplinary diversity null hypothesis: Teams with more disciplinary diversity will have more creative output.

One important issue is that different scientific disciplines can result in conflicting demands on individual researchers (Jackson, Ribes, Buyuktur, & Bowker, 2011). Moreover, research timelines between interdisciplinary collaborators may conflict (Jackson et al., 2011). A computer scientist who mostly publishes in conferences will expect a much shorter publication time frame than an economist who publishes in journals. The time to conduct research can vary widely as well. An economist may spend a few months using controlled social experiments to

gather data, while a qualitative social scientist may study the interactions in a cancer clinic for years before gathering enough data to perform an effective analysis. These temporal conflicts imply that researchers from fields with similar research rhythms are more likely to progress toward the collaboration's goals, and the collaboration will proceed more smoothly than collaborations with very different research rhythms (Jackson et al., 2011).

Moreover, interdisciplinary collaboration often requires extra time and communication due to lack of common ground regarding domain knowledge and jargon (Castán Broto, Gislason, & Ehlers, 2009; Mauz, Peltola, Granjou, van Bommel, & Buijs, 2012; Pennington, 2011a; Podestá, Natenzon, Hidalgo, & Toranzo, 2012). Both disciplinary jargon and agreement on methods are rooted in disciplinary culture and norms, which are instilled early in a researcher's career (Akerlof & Kranton, 2005). Researchers from related fields have some overlap in domain knowledge and a common language (Faniel & Zimmerman, 2011). Additionally, researchers in similar fields are more likely to agree on what constitutes high-quality research (Birnholtz, 2007). All of these factors imply that communication between researchers in similar disciplines should be more effective due to greater disciplinary common ground. In turn, more effective communication should lead to better creative outcomes from the collaboration.

Disciplinary diversity hypothesis: Increased disciplinary similarity, or less disciplinary diversity, among members of a project will be associated with more creative output.

4.2.6 Previous interactions

The founders of MCubed designed it around the assumption that innovation arises from new interdisciplinary collaborations. This was described as "no similar or identical work exists between the collaborators" (Zurbuchen, 2012). The belief that interaction creates innovation—particularly outside one's discipline—is cited by the founders of MCubed as the reason behind their emphasis on new collaborations (Zurbuchen, 2012). The implicit assumption is that new interactions are more likely to foster innovation. To support this assumption, some evidence exists that changes in team membership, particularly in teams that have been together for a shorter period of time, were more creative (Reiter-Palmon et al., 2011).

95

Previous interactions null hypothesis: Teams that have not worked together previously will have more creative output.

Many researchers describe collaboration as a "marriage," with the same need for trust, communication, and mutual respect, all of which take time to develop (Hara, Soloman, Kim, & Sonnenwald, 2003; Schunn, Crowley, & Okada, 2002). Two important aspects of a collaboration are the amount of trust between group members, and the openness to entertaining new ideas (Hemlin, 2009; Sonnenwald, 2003). Lack of trust can hinder the transfer of knowledge between collaborators, because researchers tend to avoid discussing the sensitive details of their research with people they do not trust (Birnholtz, 2007; Phelps et al., 2012). Without that exchange of knowledge, the likelihood of a collaboration's success becomes much less likely (Shrum, Chompalov, & Genuth, 2001). In contrast, mutual trust eases the transfer of knowledge between collaborators, thereby increasing the likelihood of the collaboration's success (Phelps et al., 2012).

Prior interaction in previous research projects often leads to increased trust (Cummings & Kiesler, 2007b; Melin, 2000). Researchers who know each other or who have previously worked together already know that they get along well and enjoy working together (Melin, 2000). They are familiar with each other's working styles, habits, and preferences (Cummings & Kiesler, 2007b; Melin, 2000). This is important when researchers work closely together because it reduces uncertainty about future behavior. Researchers are more confident that there will be no nasty surprises later in the collaboration (Schunn et al., 2002). When people are already familiar with the work and communication habits of their collaborators, they are more likely to collaborate successfully (Gardner, Gino, & Staats, 2012; Melin, 2000).

Prior interactions hypothesis: Prior experience working together will positively impact the creative output from collaborations.

4.2.7 Group coordination

The most successful collaborations use coordination mechanisms, such as regular face-to-face meetings (Cummings, 2005; Ribes & Finholt, 2007). Other effective coordination mechanisms include sharing resources and exchanging knowledge, often through shared databases and software (Cummings & Kiesler, 2007b; 2008; Velden & Lagoze, 2012b). The time taken by collaborators to reach agreement regarding project plans, timelines and scheduling, resource acquisition and task distribution, data handling, and identifying collaboration goals, is an indication of the amount of coordination occurring in a collaboration (Cummings & Kiesler, 2007b; 2008; Hernandez, 2012; Newman, 2001; Schunn et al., 2002). Agreement on software and other technical tools is a critical component of this type of coordination.

Researchers create and manipulate objects that are entirely made up of digital bits, and research at the university level is no different (Monteiro, 2010). Databases and other software act as a concrete record of the abstract concepts the group has thought about and discussed (Gaggioli, Riva, Milani, & Mazzoni, 2012). These tools make the cognitive work of discussing and developing new ideas easier for collaborators (Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Shaw, 2010). The question then becomes: how do these tools change the timing of team creative output? Many argue that the ease of digital communication and data exchange should serve as lubrication to the gears of collaboration, resulting in faster dissemination of research results, through both traditional peer-reviewed channels and more informal methods. However, research has shown, time and again, that sharing data and information is not nearly as simple as publishing a few files. A vast array of rich contextual data exists that is known only to the individuals who generated or processed the data. This is not at all uncommon on teams. Anyone who has worked in business knows that the person most knowledgeable about that business is the person in charge of IT services, because they must know how all of the separate data sources tie together.

> Group coordination hypothesis: Use of coordination mechanisms, such as shared databases and cloud-based collaboration tools, will be associated with increased creative output (Cummings, 2005; Cummings & Kiesler, 2007a; 2008).

4.2.8   Early feedback

Research on scientific communication suggests that researchers commonly present their results in a variety of venues prior to peer-reviewed publication (Garvey & Griffith, 1971; Garvey, Lin, Nelson, & Tomita, 1972a). As mentioned in Chapter 3, between 15% to 50% of research is presented in lightly-reviewed conferences prior to peer-reviewed publication (Schunn et al., 2002; Thelwall & Kousha, 2008). Other studies estimate that one third of technical reports are later published in peer-reviewed venues (Garvey & Griffith, 1971). These early research dissemination efforts can be instrumental in shaping research results into a final, peer-reviewed publication (Garvey & Griffith, 1971; Garvey, Lin, Nelson, & Tomita, 1972a). This—along with the correlations presented in Chapter 3 between non-reviewed, lightly-reviewed, and peer-reviewed publications—suggests that prior dissemination of research results will have a positive effect on peer-reviewed publication.

> Prior dissemination hypothesis: Early dissemination of research results through informal departmental presentations, non-reviewed written materials, and lightly-reviewed venues will be associated with increased creative output.

4.3   Methods

In this section, I detail the methods used to collect and analyze the data. First, I discuss the general types of data collected, and the methods used to perform that data collection. Second, I describe the variables used in the analysis, and how those variables are operationalized. Finally, I describe the analysis process itself.

4.3.1   Population of interest

Projects funded by the MCubed initiative is the unit of analysis for this study. Each individual may have multiple research projects at any given time. Additionally, individual collaborators often shift, especially in a university setting, as students graduate and faculty members move to new career opportunities. While these individuals generate data, analyze data, and write papers, those research outputs are directly related to a single research project. The interaction of individual collaborators is a critical aspect of the questions of interest in this study: how team diversity along multiple facets affects the creative output of the team.

4.3.2 Data sources

The data for this chapter came from a variety of sources, including multiple surveys, administrative data from university data warehouses, MCubed website log files, and publication data for the researchers funded through the MCubed process.

4.3.2.1 Survey Data

Survey data for this analysis came from the MCubed Evaluation second and third faculty surveys. The second MCubed Evaluation faculty survey was sent to all MCubed token holders, and the third MCubed Evaluation faculty survey was sent to all MCubed token holders and a matched control population. The particular questions used in this analysis were only presented to funded token holders. The second MCubed Evaluation survey was deployed in October and November 2013, and the response rate for funded token holders was 44.6%. The third MCubed Evaluation survey was deployed in October 2014 with a response rate for funded token holders of 34.8%. See the MCubed Evaluation technical appendix for further details (Traugott, Kervin, Kimmel, & Howell, 2015).

In addition to the MCubed evaluation surveys, Valerie Johnson from the MCubed administrative team gave me the results from the registration survey for the second MCubed Symposium, which took place on October 8–9, 2014. In this survey, funded token holders were asked to list a variety of outputs from their MCubed funded project; specifically, invention reports, publications, internal and external funding, and artistic and other products. Where the MCubed Evaluation Survey just asked if a project had produced a particular type of output, the MCubed Symposium survey asked respondents to fill in a citation where possible.

4.3.2.2 CV data

Complete CVs were used for the purpose of determining research output, because truncation would not provide information on all types of research output required for this study. This meant that 156 CVs ere used to compile data for this study. See Chapter 2 for a detailed description of the CV collection process.

4.3.2.3 MCubed data

Researchers could only receive funding through the MCubed website. Each token holder on the MCubed website was associated with the university unit of their primary appointment.

The website allowed token holders to create project descriptions and find collaborators, but only projects on the MCubed website were eligible for MCubed funding. The MCubed website was therefore a critical resource for researchers pursuing MCubed funding. All relevant researcher actions, such as project creation, page views, committing tokens, and cube requests, were logged on the MCubed site, and each action was time-stamped. This log data, combined with data available on the MCubed website itself, provided key information regarding the MCubed process. See Chapter 2 for more details regarding the MCubed website log files. The website usage data was also linked to survey and administrative data.

Some variables were based on information from the Memoranda of Understanding (MOUs) submitted to the MCubed administrative team by the individual university units. Valerie Johnson from the MCubed administrative team shared the unit MOUs with the MCubed Evaluation. Most of the MOUs contained information on how many tokens a unit would distribute, the maximum number of tokens a unit would fund, and the amount of money the unit would contribute to each token.

4.3.2.4 Administrative Data

The surveys and MCubed data were supplemented by data from the university data warehouse, including demographic data and proposals submitted by researchers who were funded through the MCubed initiative. A total of 6,125 proposals were submitted by MCubed token holders between 2002 and 2012 (Traugott et al., 2015).

4.3.2.5 Publication Data

Most studies regarding interdisciplinary research use publications as a benchmark to determine an organization's academic discipline. I decided to use metadata associated with a researcher's previous publications as a measure of the academic discipline of those researchers. There are many places to compile a list of publications for researchers, but they all have caveats that make using those tools potentially problematic. CVs provide an accurate and relatively complete list of publications, but automatically extracting data from CVs programmatically is difficult. The University of Michigan has experts.umich.edu, which compiles publication lists for researchers based on Scopus results. The structured nature of this list is beneficial, but experts.umich.edu only includes researchers from certain departments, mostly in engineering and medicine. The Thompson Reuters Web of Science has a variety of tools to make name

disambiguation simpler, but there is no software interface to automate the search. The University of Michigan library had a software interface and returned structured data, which made it the simplest to automate through software scripts.

4.3.3   Process for collecting publication data

The problem with using the U-M library search API was name disambiguation, or distinguishing between two different researchers with very similar names. For example, there are many researchers with the name Robert Smith or Yan Chen, sometimes even in the same university department. Newman avoided the name disambiguation problem by concentrating on specific, specialized academic fields (Newman, 2001). Alternately, Leydesdorff looked at all academic fields (Leydesdorff & Rafols, 2012). In both of these cases, identifying the articles associated with a particular researcher is not critical to the outcome. The problem for this analysis was that the population of interest was limited to specific researchers in a wide range of academic fields, rather than all researchers in one or two academic fields.

Many researchers with common names had thousands of search results. Even people with a relatively uncommon name and fewer than fifty search results could have name disambiguation issues. I tried to narrow the search results by adding extra search parameters. This included adding middle initials, using email addresses, and specifying that the researcher's institution was the University of Michigan. None of these strategies resulted in a complete list of a researcher's publications. Many researchers only sporadically use their middle initial, and not all publications include email addresses or institution names in the summary description of an article. I felt that this was a reasonable trade-off because my goal was to get a rough idea of field, rather than perform an exhaustive analysis of a researcher's publications.

While these search strategies helped, they did not completely address the name disambiguation problem. Most researchers who focus on name disambiguation use article features to identify different authors (Smalheiser & Torvik, 2009; Torvik, Weeber, Swanson, & Smalheiser, 2004). These features typically include publication journal, author- or editor-assigned keywords, and keywords extracted from the abstract. I used a combination of assigned keywords and journals to automate as much of the name disambiguation process as possible. Abstracts were only available in a few cases, so I did not use them.

While performing a library search, I linked the publication venue and assigned keywords to each article. I used this information to create sets of articles. Articles were grouped into a set if they had three or more keywords or journals in common. I used journals in addition to keywords, because about 18% of the articles did not have keywords. Depending on the researcher, the percentage of articles without associated keywords ranged from just under 10% to just over 30%. The algorithm ignored multidisciplinary journals such as *Science* or *Nature*. After this process, the number of article sets associated with each author ranged from 1 to 36.

The next step required human intervention. For authors with more than one set of articles, I manually accepted or rejected each set based on the keywords found in publicly-available descriptions of the author's research, such as that found on U-M departmental websites. This often took two rounds of investigation. In the first round, I scanned the author's description of her work, looking for keywords I could match to the keywords associated with an article set. If I found no matches, I searched for specific keywords in the author's list of publications on his website or CV. In each case, I looked for at least three matching keywords before accepting the set. I rejected an article if I could not match the previously compiled keywords describing an author's research to a set of keywords associated with the article..

4.3.4 Operationalization of variables

The following section describes the methods I used to translate the concepts described in the literature review into variables for use in the analysis. First, I describe the dependent variables. Then, I describe the control and independent variables.

4.3.4.1 Project Output (Dependent Variables)

Most creativity research evaluates the creative process by assessing how creative is the output of that process (Hennessey & Amabile, 2010). Previous scholarly research has used peer-reviewed publications as the gold standard for successful or innovative research. As I discussed in Chapter 3, this standard has certain limitations: it is temporally removed from the creative, and often messy, process of performing innovative research.

The Scholarly Arc overcomes these limitations by including early research outputs to the scope of measured research output. Using the Scholarly Arc, my analysis includes projects that have produced results but have not yet had sufficient time to produce peer-reviewed output—rather than considering them as simply failing to produce a peer-reviewed publication. It will

also allow me to understand what factors influence early progress on a research project, rather than simply the factors that influence peer-reviewed publication.

I constructed the Scholarly Arc research output variables using multiple data sources: the third MCubed Evaluation faculty survey, the registration survey for the second MCubed Symposium, and collaborator CVs. The questions from the third MCubed Evaluation faculty survey were only presented to funded token holders. This series of questions asked whether the MCubed funded project had produced or would produce a specific type of output. These outputs were journal articles, conference presentations, patents, performances, and other research products (see Q84, Q113, Q124, Q263, Q89, Q90a, Q90b, and Q56 under MCubed Evaluation Faculty Survey 3 in the Technical Appendix). Details regarding the construction of these variables can be found in 3.2.5.2, "Quantitative verification: Correlations of Scholarly Arc categories."

Based on the correlations in Table 4-1, I chose to use the condensed version of the Scholarly Arc with three categories: peer-reviewed output, lightly-reviewed output, and informal/non-reviewed output. This also had the added benefit of increasing the number of cases that could be used in this analysis from 86 to 99 after accounting for missing data in other variables, such as the ones constructed from survey data.

	Peer Reviewed	Lightly Reviewed	Informal/ No Review	N
All funded projects with output data	45.9% (n=196)	66.4% (n=125)	84.1% (n=126)	196/ 125/ 126
Projects in analysis*	45.5%	67.7%	81.8%	99

Table 0-1: Distribution of dependent variables

* No missing data on variables of interest

4.3.4.2 *Field Publication Speed*

Different academic fields tend to produce peer-reviewed output at different rates. For example, researchers in computer science predominantly publish in peer-reviewed conferences. The time between submission and publication for these conferences is usually less than a year. For example, the Association for Computing Machinery (ACM) Computer Human Interaction (CHI) conference is the top publication venue for Human Computer Interaction, according to

Google Scholar Metrics (Scholar, n.d.). Paper submissions for ACM CHI are due in late September, and are published in early to mid-May of the following year. In contrast, the *Journal of Applied Economics* took 39 weeks in 2014 from acceptance to publication, which does not include the time between submission and acceptance (Economics, n.d.). A research team wanting to publish in journals with this type of lead-time might still have been in the process of getting their work published at the time the data for this analysis were collected. Based on this wide range, I included a variable to control for publication speed.

Finding the time from submission to publication was not possible for many journals, such as the *Journal of Applied Economics*. Therefore, I decided to use a more coarse-grained measure. Publishing in peer-reviewed conferences seemed to be a driving factor behind speed of publication, so I chose to designate projects from units with researchers that primarily publish in conferences as quick-to-publish projects, and all others as slow-to-publish. Based on the findings from Chapter 3, units that primarily had researchers from Computer Science were designated as quick-publication fields, namely Engineering and Information.

4.3.4.3 Gender

Previous research has shown that the gender distribution of research teams can impact creative output (Bell et al., 2011; Bozeman & Corley, 2004; Rhoten & Pfirman, 2007). Gender distribution involves two main aspects: the gender mix, and which gender is in the majority. While these are a good starting place, they do not capture the potential difference between teams that are all male or all female. With this in mind, I operationalized gender distribution as the number of women on a funded MCubed project. This worked well in the MCubed setting, because all projects were composed of exactly three collaborators.

	All funded projects	Projects in analysis
0 women	33.8%	31.3%
1 woman	41.4%	38.4%
2 women	19.4%	21.2%
3 women	5.4%	9.1%
Total N	222	99

Table 0-2: Percentage of women on a project

4.3.4.4   Ethnicity

Research suggests that ethnic diversity in a team has an impact on research output, although researchers differ on the nature of that impact (Bell et al., 2011; Freeman & Huang, 2014). Ethnicity is a complex and multi-faceted concept, even at the individual level. When compiling this multi-faceted information to a project level, the range of possibilities grows even more, as hinted at in Table 4-3.

	All funded projects	Projects in analysis
All White	35.6%	33.3%
2 White, 1 Asian or Other	40.1%	46.5%
1 White, 2 Asian or Other	18.9%	18.2%
All Asian or Other	5.4%	2.0%
Total N	222	99

Table 0-3: The ethnic mix on a project

Despite this complexity, prior research indicates that the key aspect of ethnicity is whether research teams are mixed. Based on this, I operationalized the ethnic diversity variable as all the same ethnicity (0) or a mix of different ethnicities (1). Note: all but one project in the "All same" category listed in Table 4-3 is composed of all-white researchers.

	All funded projects	Projects in analysis
All same ethnicity/race	38.7%	34.3%
Mixed ethnicity/race	61.3%	64.7%
Total N	222	99

Table 0-4: Ethnicity of project collaborators

4.3.4.5   Tenure status

Previous research indicates that the combination of an individual's personal knowledge and the knowledge contained in that person's personal network tends to increase innovation. Unfortunately, there is no direct way to measure this theoretical concept, so a proxy measure is required. In order to get tenure, researchers must prove that they have had a positive impact on their field, and that others in their field recognize that impact. Both of these tenure requirements are reflections of a researcher's personal knowledge, and the extent of the researcher's professional network. I used the number of tenured faculty on a project as a proxy measure for the size of the knowledge base available to project collaborators. For this analysis, a tenured

faculty member was defined as anyone who was tenure tracked and did not have "assistant" in his or her title.

	All funded projects	Projects in analysis
No tenured faculty	9.9%	9.1%
One tenured faculty	29.3%	35.4%
Two tenured faculty	37.4%	33.3%
Three tenured faculty	23.4%	22.2%
Total N	222	99

Table 0-5: Number of researchers in a project with Associate rank or higher

4.3.4.6   MCubed Process

It is possible that the MCubed process could have affected the ability of collaborators to produce output. First, projects that were funded in the first two phases received funding by January 2013, while most of the projects that were funded in the third phase did not get funding until April or May 2013. The delay in receiving funding might have impacted whether there was output, and the type of output from that project. This meant that the MCubed funding phases should be included in the outcome analysis. Second, some collaborations formed faster than others, indicating that these projects may have already been in progress, and that the collaborators were simply looking for extra funding to continue that project.

	All funded projects	Projects in analysis
1st phase (semi-random)	22.5%	22.2%
2nd phase (random)	53.2%	54.5%
3rd phase (first come, first serve)	24.3%	23.2%
Total N	222	99

Table 0-6: Number of projects funded in each MCubed funding phase

	All funded projects	Projects in analysis
Minimum	0	0
Mean +/- std. dev.	16 +/- 31	16 +/- 32
Median	3	4
Maximum	208	208
Total N	222	99

Table 0-7: Distribution of the number of days for projects to form

4.3.4.7   Institutional support

Multiple studies show that the institutional environment surrounding collaborators on a research project can affect the output from that project (Amabile et al., 1996; Evans, 2010; Haas & Park, 2010; Hennessey & Amabile, 2010; Knorr-Cetina, 1982; Sutton & Hargadon, 1996). Many factors contribute to the overall institutional environment, such as the norms reflected by colleagues, and the amount of resources available to support a project. Unfortunately, departmental climate and norms can be hard to directly quantify. On the other hand, generally available resources are more easily quantified. One proxy measure for institutional support is how much each department spent on encouraging interdisciplinary collaborations. One could identify the amount of money each department was willing to spend on the MCubed project as a proxy for the extent to which a department was willing to support interdisciplinary collaboration. I chose to use the actual amount spent, because the College of Literature, Science, and the Arts (LSA) agreed to fund 100 tokens in Natural Sciences, 100 in Social Sciences, and 100 in Humanities. At first glance, this would put Natural Sciences and Humanities on a level playing field. The reality is that Humanities departments within LSA typically have dramatically less money available than their Natural Sciences counterparts. For this reason, I chose to focus on the actual amount spent. This ranged from $0 in the Institute for Social Research (ISR) to $900,000 in Medicine. One of the challenges with interdisciplinary collaboration is that multiple organizations are contributing to the institutional environment surrounding an interdisciplinary collaboration. In theory, projects that had collaborators from units with very different levels of support for interdisciplinary collaborations could encounter extra difficulties. Because of this, I used the difference between the maximum amount a project collaborator's unit spent, and the minimum amount a project collaborator's unit spent.

	All funded projects	Projects in analysis
Minimum	27,217	27,217
Mean +/- std. dev.	434,428 +/- 279,661	407,559 +/- 255,511
Median	446,408	409,617
Maximum	900,000	900,000
Total N	222	99

Table 0-8: Difference between the total dollars spent on MCubed by project collaborators' units

4.3.4.8 Disciplinary diversity

There are conflicting theories on the benefits of interdisciplinary collaboration. One stream of research suggests that interdisciplinary collaboration produces more innovative solutions (Bell et al., 2011; Hargadon & Sutton, 1997; Page, 2007a; Uzzi & Spiro, 2005). On the other hand, disciplinary differences could negatively impact the collaborative process in a research project for many reasons, such as theoretical and methodological differences, or disciplinary jargon (Akerlof & Kranton, 2005; Birnholtz, 2007; Castán Broto et al., 2009; Faniel & Zimmerman, 2011; Jackson et al., 2011; Mauz et al., 2012; Pennington, 2011b; Podestá et al., 2012).

In attempting to reconcile these differing perspectives, one must first define what is meant by interdisciplinary collaboration. The MCubed administrative team chose to define an individual researcher's discipline by the school, college, or institute where he or she had a primary academic appointment. By this definition, all of the MCubed projects were interdisciplinary collaborations, because they involved researchers from two or three different departments. Projects with collaborators from three different units or departments were considered more interdisciplinary than projects with collaborators from two different units.

This definition of interdisciplinary collaboration is fairly coarse. Many faculty members at U-M have joint appointments in multiple departments. In cases where faculty members have two 50% appointments, deciding which department is primary may be somewhat arbitrary. For example, one project had two collaborators with a 50% appointment at the College of Engineering, and the third collaborator had a 100% appointment at the College of Engineering. All collaborators had their appointments in the same department at the College of Engineering. While this project met the MCubed definition of an interdisciplinary collaboration, the research areas of the collaborators were actually quite closely related. While the number of units represented in a MCubed project was a coarse measure of the degree of interdisciplinarity, I included it in my logistic regressions in order to understand if that measure was sufficient to capture that concept.

I decided that a more granular measure of the degree of interdisciplinarity in a collaboration was necessary. To begin, I felt that the MCubed definition of interdisciplinary research lacked nuance. Many definitions of interdisciplinary research focus on the idea of integrating insights from specialized bodies of knowledge to solve a practical problem (Repko,

2007). Others go further, emphasizing the importance of integrating the various disciplinary tools, such as theories and methods (Repko, 2007). These definitions provided the details I felt were lacking in the MCubed definition.

That left me with the question of how to measure the degree of interdisciplinarity in a given research collaboration. There have been numerous attempts to quantify interdisciplinary research, with each method having advantages and disadvantages. One popular method is to use the ISI Subject categories listed in the Web of Science (Leydesdorff & Rafols, 2012; Rafols, Porter, & Leydesdorff, 2010; Sonnenwald, 2008; Wagner et al., 2011). Another set of methods uses the abstracts and full text from an author's published articles to create a topic model of that author's research (Blei & Lafferty, 2007; Jo, Hopcroft, & Lagoze, 2011; Li et al., 2010). Co-authorship networks are another common method (Ding, 2011; He, Ding, Tang, Reguramalingam, & Bollen, 2013). Finally, some studies have tried to establish a researcher's career trajectory (Gläser & Laudel, 2009).

At first glance, using the subject categories listed in the Web of Science is appealing because this method is somewhat standardized. Unfortunately, this measure is best used for journals or large research organizations, rather than for individuals (Leydesdorff & Rafols, 2012; Rafols et al., 2010). The authors of this method specifically stated that their methods were not reliable for individuals with fewer than 135 publications (Rafols et al., 2010). Many of the MCubed funded researchers did not have this many publications because they were early in their careers, and from fields that did not publish large numbers of articles, or both. To further complicate matters, the Web of Science does not include many conferences, which are a key publication venue in certain fields such as Computer Science. Between these two factors, using the method proposed by Leydesdorff and Rafols was not a viable option.

Another option was to use the actual content of an author's publications to generate a topic model (Blei & Lafferty, 2007). This method is most useful if at least the abstract, and ideally the full text of each paper, is available; and is relatively easy to implement in fields where researchers are required to submit their work to PubMed. However, this is not the case across all the fields represented by the faculty members used for this analysis, which ruled out topic modeling in assigning a discipline to a given researcher. In fact, this lack of availability disqualified any method that used abstracts or text to assign a topic to an author (Jo et al., 2011; Li et al., 2010; Rosvall & Bergstrom, 2008; Velden & Lagoze, 2013).

Using co-author networks was an option because data was available from the University Library. Unfortunately, many of the measures that use co-author networks combine topic modeling to get a sense of the field (He et al., 2013; Jo et al., 2011; Velden & Lagoze, 2013). Because the data required for topic modeling was not available, these measures would not work. One measure relied solely on the co-authorship network, but the co-authorship network measures collaborative ties rather than disciplinary similarity (Ding, 2011). The strength of the collaborative ties did not address the question I needed for this variable, which was: how similar are the disciplines of the funded MCubed project collaborators?

Finally, a set of studies has looked at the career trajectories of individual researchers, as research interests change over a lifetime of research (Gläser & Laudel, 2009; Hellsten, Lambiotte, Scharnhorst, & Ausloos, 2007; Rhoten & Pfirman, 2007). While these studies were useful in understanding the overall research trajectory of an author, they did not result in a quantitative measure of that trajectory. Additionally, gathering the data necessary for three hundred collaborators was not practical.

The data needed to cover a wide range of fields and publication venues was the main constraint when considering data sources for creating this variable. Many sources for publication data such as experts.umich.edu only include publication data from certain fields such as engineering and medicine (as was the case for experts.umich.edu). Fortunately, the University Library catalogs a wide range of publications from a variety of venues to serve U-M's diverse researcher population. Using information from the University Library allowed me to overcome many of the field-based limitations of gathering information. Unfortunately, I was limited in the information available through the library search API. The availability of abstracts and full text was sporadic at best. In contrast, information on co-authors, titles, journals and/or conferences, and keywords associated with each publication, was readily available. While keywords were not universally available, they were available about 82% of the time.

Given the data available to me and the limitations of existing methods, I decided to take a different approach. I used the keywords associated with each article published by the project collaborators, using the keyword sets generated during name disambiguation, described above. To calculate a project level score of disciplinary similarity, I used the Jaccard Index (Leydesdorff, 2007), which contains the number of items in the intersection of two or more sets divided by the number of items in the union of the same sets. To calculate an interdisciplinary measure for the

project, I calculated the Jaccard Index of the set of keywords associated with each of the three collaborators in each project.

	Projects in analysis
Minimum	.000
Mean +/- std. dev.	.006 +/- .009
Median	.003
Maximum	.057
Total N	99

Table 0-9: Distribution of Jaccard Index of keywords for projects in analysis

To make the regression results more easily interpretable, I multiplied the Jaccard Index scores for each project by 100. Using this variable, higher numbers indicate more similarity in collaborator fields, and lower numbers indicate more diversity in collaborator fields.

4.3.4.9   Prior interactions

Trust and communication are two key factors in a successful collaboration (Birnholtz, 2007; Hara et al., 2003; Hemlin, 2009; Phelps et al., 2012; Schunn et al., 2002; Sonnenwald, 2003). Prior interactions—in particular, working on previous research projects—is one of the main ways to develop mutual trust (Cummings & Kiesler, 2007b; Gardner et al., 2012; Melin, 2000; Schunn et al., 2002). Essentially, the collaborators are already familiar with each other's working styles and habits. I chose to operationalize prior interactions as the number of dyads in a project that had previously collaborated on a funding proposal between 2002 and 2012. The major benefit of using proposal data is that administrative data was available for all funded MCubed projects, so the number of cases available for this analysis was not negatively impacted. Moreover, Long & Freese suggest that the minimum number of cases to use in a logistic regression is 100 (Long & Freese, 2006).

# of dyads with prior proposals	All funded projects	Projects in analysis
0 Dyads	58.6%	60.6%
1 Dyad	32.0%	27.3%
2 Dyads	3.6%	5.1%
3 Dyads	5.9%	7.1%
Total N	222	99

Table 0-10: Number of projects whose collaborators had previously collaborated on a funded proposal

While there are limitations inherent in this choice, they are reasonable given the sample frame of projects. The primary limitation is that certain fields are more likely to pursue funding than others. For example, scholars in art- or humanities-related fields are less likely to pursue external funding proposals. In contrast, researchers in medicine, engineering, or the natural sciences regularly write proposals targeted toward the National Science Foundation (NSF) or the National Institutes of Health (NIH). Because the majority of projects funded through MCubed are from Medicine, Engineering, and the Natural Sciences departments, using proposals was a reasonable option.

An additional potential limitation was that the number of joint proposals and field diversity could be highly correlated. To test this, I created a box-plot comparing the number of pairs of collaborators with the joint-proposals-to-the-field similarity measure described above (see Figure 1). In addition, I also calculated the Pearson correlation for these measures. The correlation was .165 at $p < .1$ for all funded projects, and .124 for the analysis dataset. While there are some differences apparent from a visual scan of the box plot, these differences are not enough to justify leaving one variable or the other out of the analysis.
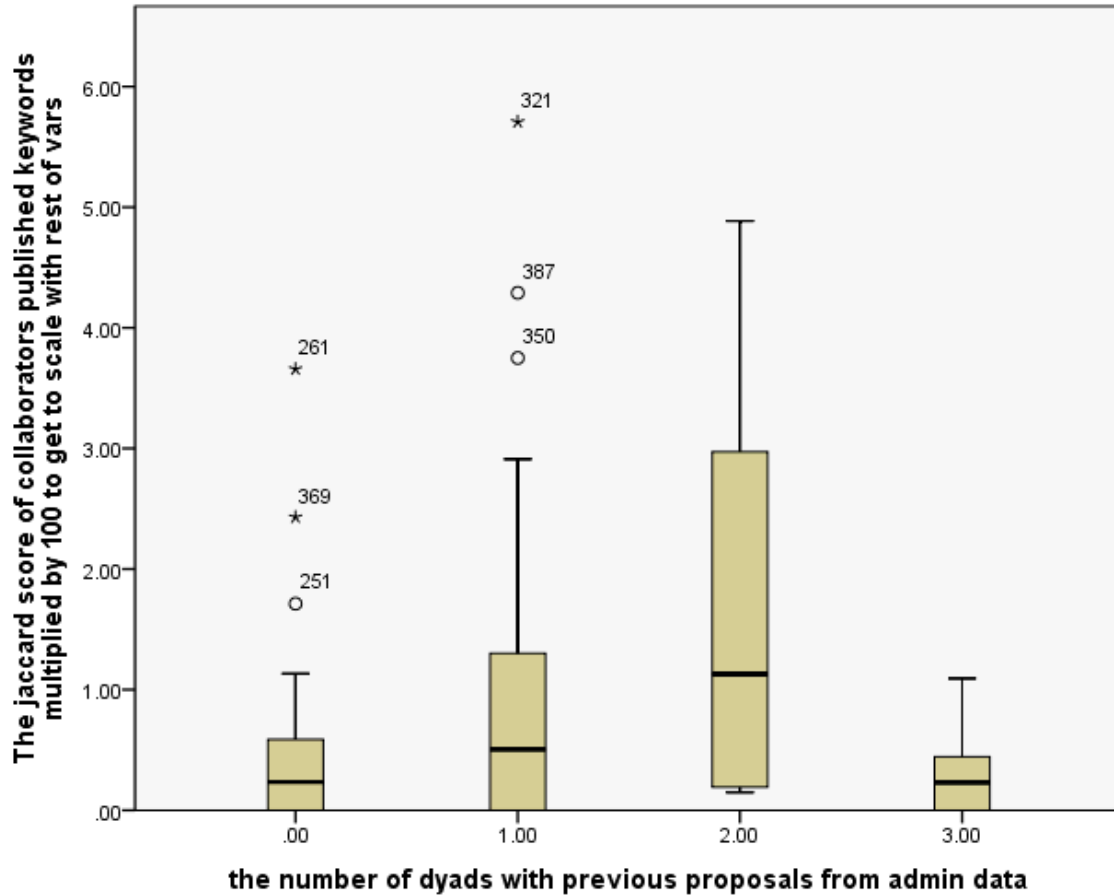
Figure 0-1: Box plot comparing number of pairs of collaborators with prior joint proposals, to field diversity

4.3.4.10 Group coordination

Successful collaborations use a variety of coordination mechanisms such as sharing resources and exchanging knowledge (Cummings, 2005; Cummings & Kiesler, 2007a; 2008; Ribes & Finholt, 2007; Velden & Lagoze, 2012a). Collaborators also use shared databases or software, which can be critical to the coordination process. These tools make discussing and developing ideas easier, and they act as a concrete record of the concepts the group has discussed and implemented (Gaggioli et al., 2012; Ilgen et al., 2005; Monteiro, 2010; Shaw, 2010). On the second and third MCubed Evaluation faculty surveys, I asked collaborators on the MCubed projects if they were using these types of technical coordination tools. (See MCubed Evaluation Faculty Survey 2: Q25, and MCubed Evaluation Faculty Survey 3: Q25, in the Appendix.) Compiling this variable to the project level proceeded in two phases. First, I generated a project level variable for each survey. If a collaborator had checked an option on either survey, the

dummy variable corresponding to that response was marked as positive. Next, I grouped these project variables into four categories. Any type of shared file repository, cloud or otherwise, was grouped into a single category. Since only 11.9% of the projects and 16.2% of projects in the analysis projects used websites, wikis, or intranets, I lumped this category with the "Other" responses. "None" was dropped from the categorization, because none was implied if none of the other categories was marked.

	All funded projects	Projects in analysis
Cloud based applications (e.g. Google Docs)	41.8%	53.5%
Shared file repositories (cloud or local)	63.9%	74.7%
Shared database	15.5%	17.2%
Other	32.5%	35.4%
Total N	**194**	**99**

Table 0-11: Types of coordination tools used by project collaborators. This was a multiple response question, so percentages could total more than 100%.

4.3.4.11 Early feedback

Getting feedback early in a research project can be instrumental in shaping the final, peer-reviewed publications that result from that research project (Garvey & Griffith, 1971; 1972). Most researchers get this early feedback by an iterative process of disseminating progressively more refined research results to progressively larger audiences (Garvey & Griffith, 1971; Garvey, Lin, Nelson, & Tomita, 1972b). Technical reports and lightly-reviewed conference presentations are exactly the types of early research outputs accounted for by the Scholarly Arc described in Chapter 3: specifically the outputs listed in the informal/non-reviewed, and lightly-reviewed categories. I included lightly-reviewed and informal/non-reviewed output in the peer-reviewed models. Unfortunately, I could not include informal/non-reviewed output in the lightly-reviewed model, because all projects in the analysis with lightly-reviewed output also had informal/non-reviewed output. Logistic models are not able to handle this type of situation.

4.3.5 Analysis methods

Because the output variables were binomial—a project either produced peer-reviewed, lightly-reviewed, or non-reviewed output—logistic regression was the analysis method of choice. A logistic regression model is linear in that "the log odds are a linear combination of the x's and β's" (Long & Freese, 2006). Log odds are difficult for the average person to easily interpret, but fortunately, log odds can be converted to an odds ratio (Ω) by raising e to the power of β_k, as illustrated by the following equation (Long & Freese, 2006):

$$\Omega = e^{\beta_0} e^{\beta_1 x_1} e^{\beta_2 x_2} e^{\beta_3 x_3} \dots e^{\beta_n x_n}$$

Where

$$\Omega = \frac{\Pr(y = 1)}{\Pr(y = 0)} = \frac{\Pr(y = 1)}{1 - \Pr(y = 1)}$$

The formula for calculating probability from odds is (Long & Freese, 2006):

$$P = \frac{\Omega}{1 + \Omega}$$

The interpretation of a coefficient in a logit regression model is "for a unit change in x_k, the odds are expected to change by a factor of $\exp(\beta_k)$" (Long & Freese, 2006).

4.4 Analysis Results

The tables below report the β_k values. When presenting the results for specific variables, only x_k changes, and all other variables are held constant (Long & Freese, 2006).

4.4.1 Peer-reviewed output

	Field pub speed	Project demog.	MCubed process	Prior interact.	Field + org. diversity	Coord.	Prior Output
Chi-Sq null[1]	.263	15.369 †	20.279 *	30.499 **	41.544 **	48.205 **	71.561 ***
Chi-Sq prev		15.105 *	4.910	10.221 *	11.044 *	6.662	23.356 ***
Log Likelihood	136.161	121.055	116.145	105.924	94.880	88.219	64.863
% Predicted	54.5%	67.7%	69.7%	78.8%	77.8%	77.8%	84.8%
Constant	-.241	-1.319	-1.821†	1.717	2.049	1.998	.539
Field Pub Speed (slow/fast)	.241	-.326	-.490	-.631	-.385	-.174	1.196

# of Women (1)	1.572 †	1.700 †	1.904 *	2.928 *	3.457 **	5.600 **
# of Women (2)	.733	.783	.839	1.618	2.024†	3.606*
# of Women (3)	.312	.215	.541	.964	1.035	3.230†
Ethnic Mix (same/diff)	.997 *	1.112 *	1.766 **	2.390 **	2.871 **	4.163 **
# Tenured faculty (1)	-1.841 †	-2.328 *	-3.078 *	-3.832 **	-4.789 **	-8.473 **
# Tenured faculty (2)	.275	.284	.192	.188	-.194	-2.442†
# Tenured faculty (3)	-.743	-.717	-1.315 †	-1.66 *	-2.166 *	-4.135 **
Fund Phase 1		1.359 †	1.129	.979	1.025	1.073
Fund Phase 2		.182	-.181	-.232	-.483	-.532
Days to Cube		.002	.001	.005	.000	-.001
# Dyads prior proposals (1)			-3.707 *	-4.878 **	-5.936 **	-7.774 **
# Dyads prior proposals (2)			-3.981 **	-5.646 **	-6.231 **	-9.039 **
# Dyads prior proposals (3)			-3.008 †	-3.941 *	-4.320 *	-5.114 *
Field similarity				.662 *	.713 *	1.451 **
Diff max unit & min unit spent				-.231 †	-.230	-.463 *
Num Units				1.187 †	1.256 †	1.910 †
Shared cloud apps					.958	1.534†
Shared files (cloud or repos)					.290	-.535
Shared DB					-1.896 †	-2.721 *
Other shared tools					.479	.160
Light Rev.						4.496 *
Informal/No Rev.						-.328

Table 0-12: Logistic regressions for peer-reviewed output, full model (N=99).

1 Percentage predicted correct by null model: 54.5%
† p < .1; *p < .05; **p < .01; ***p < .001

The relative speed of publication in a field did not appear to have a statistically significant effect on whether a project published in a peer-reviewed venue. The MCubed process itself also did not have a statistically significant effect on the likelihood of a project publishing in a peer-reviewed venue. Being funded in the first MCubed funding phase approached statistical significance, but disappeared when other factors were taken into account. Additionally, prior non-reviewed/informal output did not have a statistically significant effect on the likelihood of peer-reviewed output.

The base odds of a funded MCubed project being published in a peer-reviewed venue can be calculated using the equation:

$$\Omega = e^{\beta_0} e^{\beta_{Gend} x_G} e^{\beta_{Eth} x_E} e^{\beta_{Ten} x_C} e^{\beta_{Prop} x_P} e^{\beta_{Field} x_F} e^{\beta_{Org1} x_{O1}} e^{\beta_{Org2} x_{O2}} e^{\beta_{Coord} x_{Cd}} e^{\beta_{output} x_{out}}$$

where variables that did not achieve a significance level of at least p < .05 are left out of the base probability calculation. The reason for this is that the null hypothesis (the variables are not equal to zero) cannot be rejected. Because the intercept was not significant, it too is left out of the base probability calculation. Based on this rule, the average hypothetical project would be a two-unit project with one large unit and one smaller unit, in terms of spending. The project would be all male and white with no tenured faculty and no joint proposals. Additionally, the hypothetical project would have an average field similarity score of 0.6, meaning that the collaborators used no coordination tools and had no lightly-reviewed output.

The base odds of publishing peer-reviewed research was:

$$\Omega = e^{5.600\times0} e^{3.606\times0} e^{4.163\times0} e^{-8.473\times0} e^{-4.135\times0} e^{-7.774\times0} e^{-9.039\times0} e^{1.451\times.6} e^{-.463\times4.3} e^{-2..721\times0} e^{4.496\times0}$$

$$= .326, or\ a\ 1\ in\ 4.07\ chance$$

The equation to calculate the base probability with these numbers is:

$$P = \frac{e^{5.600\times0} e^{3.606\times0} e^{4.163\times0} e^{-8.473\times0} e^{-4.135\times0} e^{-7.774\times0} e^{-9.039\times0} e^{1.451\times.6} e^{-.463\times4.3} e^{-2..721\times0} e^{4.496\times0}}{1 + e^{5.600\times0} e^{3.606\times0} e^{4.163\times0} e^{-8.473\times0} e^{-4.135\times0} e^{-7.774\times0} e^{-9.039\times0} e^{1.451\times.6} e^{-.463\times4.3} e^{-2..721\times0} e^{4.496\times0}}$$

This simplifies to:

$$p = \frac{e^{1.451\times.6} e^{-.463\times4.344}}{1 + e^{1.451\times.6} e^{-.463\times4.344}} = .246 = 24.6\%$$

117

It should be noted that most projects do not reflect this base case. For instance, only about 9% of the projects included in the analysis had no tenured faculty, and only about one third of the projects were ethnically homogeneous. Note: all 95% confidence intervals are reported as odds ratios.

4.4.2 Lightly-reviewed output

Running a model with lightly-reviewed output as the dependent variable required a few changes in the independent variables. The model could not converge on a final solution with number-of-dyads-with-joint-proposals as a categorical variable, so this was run as a simple count. This inability to converge was because projects where all three pairs of collaborators had a prior proposal also all had lightly-reviewed output. The same problem occurred when using non-reviewed/informal output as an independent variable, so that variable was removed from the model. All other variables remain the same.

	Field pub speed	Project demog.	MCubed process	Prior interact.[2]	Field + org. diversity	Coord.
Chi-Sq null[1]	.015	9.199	11.207	11.328	11.710	22.280
Chi-Sq prev		9.185	2.007	.122	.382	10.570 *
Log Likelihood	124.583	115.399	113.391	113.269	112.888	102.318
% Predicted	67.7%	68.7%	71.7%	71.7%	71.7%	72.7%
Constant	.754 **	-.181	-.337	-.390	-.470	-1.758
Field Pub Speed (slow/fast)	-.061	-.500	-.524	-.546	-.518	-.494
Gender (1 woman)		.317	.330	.361	.380	.457
Gender (2 women)		.516	.552	.573	.605	.432
Gender (3 women)		-.903	-.985	-.939	-.916	-1.159
Ethnic Mix (same/diff)		.275	.313	.346	.314	.525
# Tenured (1)		.715	.505	.501	.482	.882
# Tenured (2)		1.441	1.399	1.409	1.454	1.911

	*	*	*	*	*
# Tenured (3)	.761	.733	.698	.704	.944
Fund Phase 1		.844	.790	.737	.373
Fund Phase 2		.074	.027	.040	-.277
Days to Cube		-.002	-.002	-.002	.001
# Dyads Proposals^2			.097	.123	.100
Field similarity				-.093	-.119
Diff max unit & min unit spent				.006	.031
Num Units				.281	.246
Shared cloud apps					-.293
Shared files (cloud or repos)					1.919 **
Shared DB					-.476
Other shared tools					.006

Table 0-13: Logistic regressions for lightly reviewed output (N=99).

1 Percentage predicted correct by null model: 67.7%
2 Estimation terminated and final solution could not be found using the categorical version of this variable, so used count instead
† $p < .1$; *$p < .05$; **$p < .01$; ***$p < .001$

Many of the factors with a statistically significant effect on the production of peer-reviewed publications did not have an effect on the production of lightly-reviewed publications. Like peer-reviewed publications, the relative speed of publication in a field did not have a statistically significant effect. The MCubed process of distributing funds also did not have an effect. Gender, ethnic mix, prior proposals, field similarity, unit support, and number of units did not have a statistically significant effect on lightly-reviewed output, unlike the peer-reviewed models.

The base odds of a project producing lightly-reviewed output were calculated using the same methodological choices as for calculating peer-reviewed output. Only variables that were statistically significant in the final model were included in the base probability calculation. Based on this, the average hypothetical project had no tenured faculty and did not use any coordination tools. Because both statistically significant variables are categorical, I included the intercept in the base probability calculation. For reference, this was significant at the $p < .15$ level.

The base odds of producing lightly-reviewed output was:

$$\Omega = \ e^{-1.758}e^{1.911 \times 0}e^{1.919 \times 0} = \ .172, or\ a\ 1\ in\ 6.8\ chance$$

The equation to calculate the base probability with these numbers is:

$$P = \frac{e^{-1.758}e^{1.911 \times 0}e^{1.919 \times 0}}{1 + e^{-1.758}e^{1.911 \times 0}e^{1.919 \times 0}}$$

This simplifies to:

$$p = \frac{e^{-1.758}}{1 + e^{-1.758}} = .147 = 14.7\%$$

As mentioned previously, most projects do not reflect this base case. Also keep in mind that the constant was not significant, although it was negative in all lightly-reviewed models except the model that included only field publication speed.

4.4.3   Non-reviewed/informal output

Running a model with non-reviewed/informal output as the dependent variable required the same changes to the independent variables as the lightly-reviewed model. The model could not converge on a final solution with number-of-dyads-with-joint-proposals as a categorical variable, so this was run as a simple count for the same reason as described in the lightly-reviewed results section. All other variables remain the same.

	Field pub speed	Project demog.	MCubed process	Prior interact.[2]	Field + org. diversity	Coord.
Chi-Sq null[1]	.937	6.950	8.781	8.828	11.411	22.879
Chi-Sq prev		6.013	1.832	.047	2.583	11.468 *
Log Likelihood	92.943	86.930	85.098	85.051	82.469	71.000
% Predicted	81.8%	81.8%	80.8%	80.8%	81.8%	85.9%
Constant	1.658 ***	1.310	1.488	1.456	1.305	-.119
Field Pub Speed (slow/fast)	-.560	-.695	-.497	-.511	-.393	-.275
Gender (1 woman)		.099	.141	.151	.326	.336
Gender (2 women)		1.207	1.334	1.338	1.449	1.249
Gender (3 women)		.128	.182	.203	.237	.213
Ethnic Mix (same/diff)		-.436	-.412	-.377	-.389	-.123
# Tenured (1)		.215	-.154	-.156	-.096	.653
# Tenured (2)		.935	.612	.611	.566	1.176
# Tenured (3)		-.156	-.463	-.492	-.468	-.274
Fund Phase 1			.452	.413	.441	-.370
Fund Phase 2			.018	-.016	.046	-.365
Days to Cube			-.009	-.009	-.008	-.007
# Dyads Proposals				.073	-.003	-.074
Field similarity					.769	.801
Diff max unit & min unit spent					-.075	-.068
Num Units					-.023	-.188
Shared cloud apps						-.121
Shared files (cloud or repos)						2.002 **
Shared DB						.502
Other shared tools						.454

Table 0-14: Logistic regressions for no-review/informal reviewed output (N=99).

1 Percentage predicted correct by null model: 81.8%
2 Proposals run as count to enable finding a solution
† p < .1; *p < .05; ** p <.01; *** p <.001

Very few factors had a statistically significant effect on the production of non-reviewed/informal output. Similar to peer-reviewed and lightly-reviewed output, the relative speed of publication in a field did not have a statistically significant effect. The MCubed process of distributing funds also did not have an effect. Like the lightly-reviewed models, gender, ethnicity, prior proposals, field similarity, unit support, and number of units did not have a statistically significant effect. Unlike either the peer-reviewed and lightly-reviewed models, the number of tenured faculty did not have a statistically significant effect.

The base odds of a project producing non-reviewed/informal output were calculated using the same methodological choices as calculating peer-reviewed and lightly-reviewed output. Only variables that were statistically significant in the final model were included in the base probability calculation. Based on this, the average hypothetical project did not use any coordination tools. Because the only statistically significant variable is categorical, I included the intercept in the base probability calculation. For reference, this was significant at the p < .9 level.

The base odds of publishing non-reviewed/informal research was:

$$\Omega = e^{-.119}e^{2.002\times0} = .887, or\ a\ 1\ in\ 2.13\ chance$$

The equation to calculate the base probability with these numbers is:

$$P = \frac{e^{-.119}e^{2.002\times0}}{1+e^{-.119}e^{2.002\times0}}$$

This simplifies to:

$$p = \frac{e^{-.119}}{1+e^{-.119}} = .470 = 47.0\%$$

As mentioned previously, most projects do not reflect this base case. Also keep in mind that the constant was not significant to a very large extent.

4.4.4 Differences in departmental environment

Based on prior literature, I hypothesized that smaller differences in tangible support for interdisciplinary collaboration by researchers' departments would be associated with increased creative output. I operationalized this as the difference in the maximum and minimum total amount the department spent on MCubed. This hypothesis was supported by the results. An increase in the difference in departmental support for the MCubed project by one unit resulted in a decrease in the odds of that project having a peer-reviewed publication by a factor of .629, holding all other variables constant. As Figure 4-2 shows, the expected probability of a peer-reviewed publication from a project with the mean difference in unit support was just under 40%, holding all other variables at their base or mean as appropriate. An increase in the difference in departmental support for the MCubed project by one standard deviation decreased the expected probability to just under 20%. When looking at lightly-reviewed and non-reviewed/informal output, organizational diversity in support of interdisciplinary collaboration did not have a statistically significant effect.

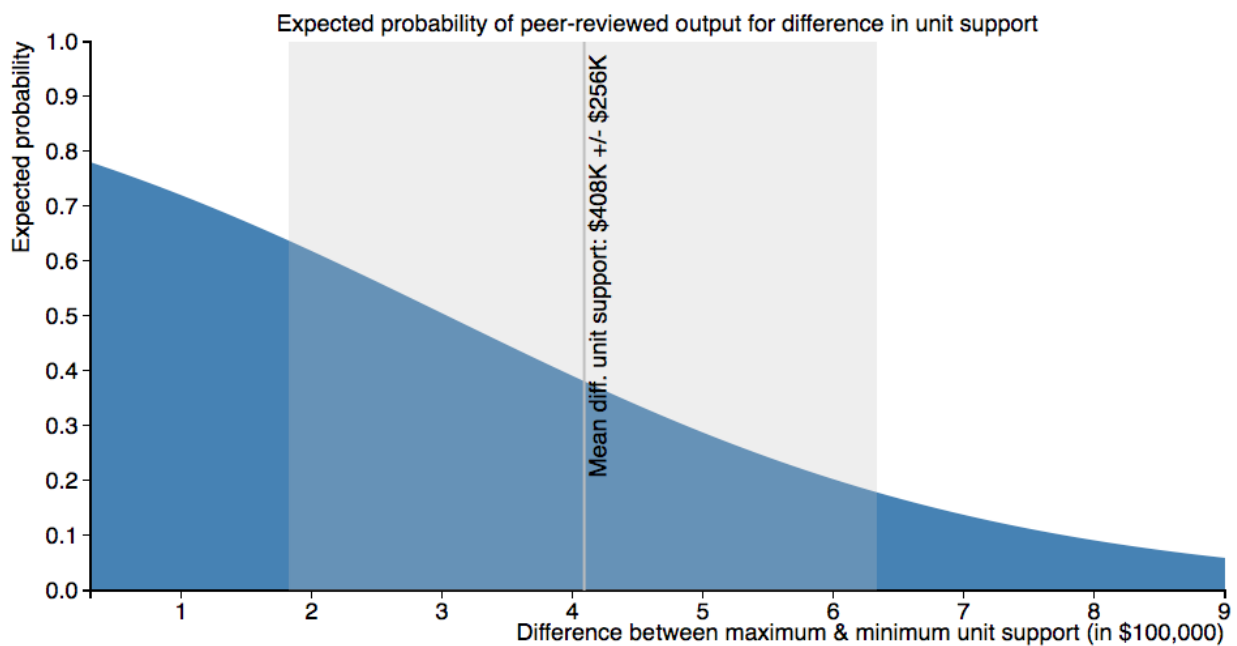**Figure 0-2: Expected probability of peer-reviewed output for difference in unit support**

4.4.5 Field diversity

The hypothesis regarding field diversity was that increased disciplinary similarity among members of a project would be associated with more creative output. When looking at peer-reviewed output, this hypothesis was verified by the results. An increase in the field similarity of

the project collaborators by one standard deviation increased the odds of producing a peer-reviewed publication by a factor of 4.269. As Figure 4-3 shows, the expected probability of a peer-reviewed publication from a project with the mean field similarity was just under 40%, holding all other variables at their base or mean as appropriate. An increase in the field similarity by one standard deviation increased the expected probability to just under 70%. When looking at lightly-reviewed and non-reviewed/informal output, field diversity did not have a statistically significant effect.
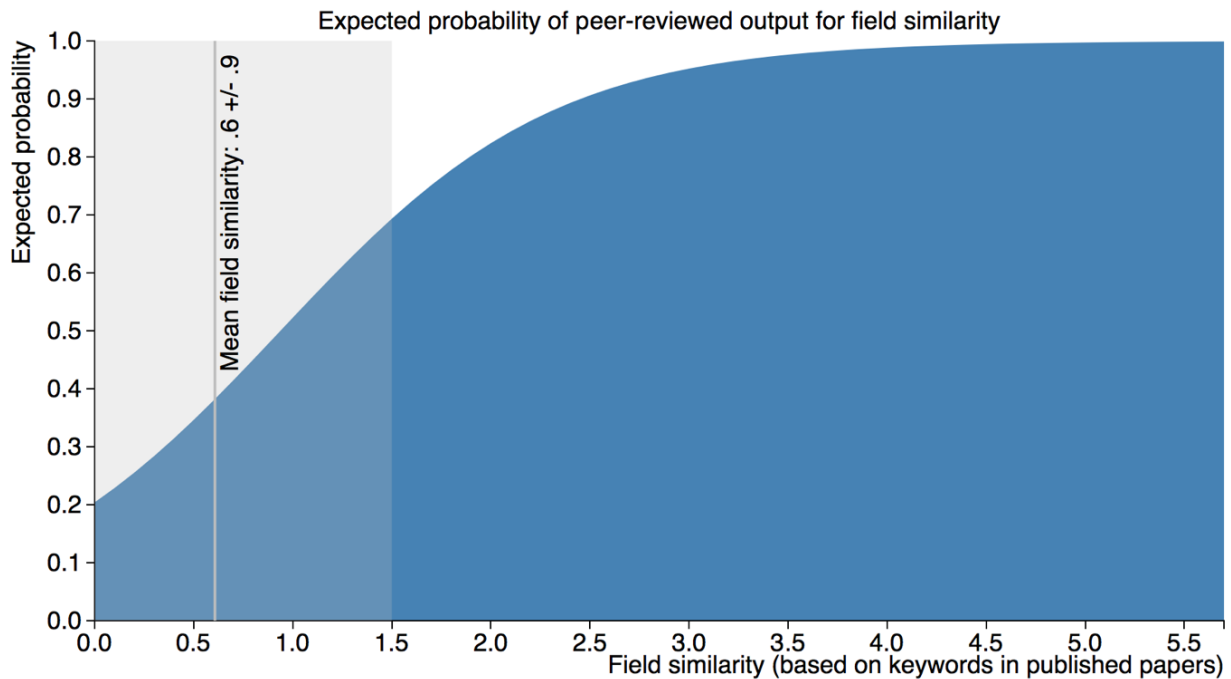
Figure 0-3: Expected probability of peer-reviewed output for field similarity

4.4.6   Prior interactions (joint proposals)

I hypothesized that collaborators with prior experience working together would produce more creative output. Using peer-reviewed publications as a measure of creative output, this hypothesis is not supported in this population. If any number of pairs of collaborators had prior joint proposals together, there was a statistically significant negative effect on the odds of publishing in peer-reviewed venues. The number of pairs of collaborators with joint proposals did not have a statistically significant effect on whether a project produced either lightly-reviewed or non-reviewed/informal output.

As Figure 4-4 shows, the expected probability of a peer-reviewed publication from a project with the mean field similarity was roughly the same for all pairs of collaborators with

prior joint proposals, holding all other variables at their base or mean as appropriate. This did not change significantly when the field similarity was increased by one standard deviation. The effect was most pronounced when project collaborators had a high degree of field similarity. The blue curve, showing projects where no collaborators had prior joint proposals, is the same curve as shown in Figure 4-3. Projects where the overlap in collaborators' fields was very similar but where none had prior joint proposals were almost certain to have peer-reviewed output. The negative impact of prior joint proposals was for projects where all three collaborators had prior joint proposals with each other. In this case, the expected probability of producing a peer-reviewed publication (or other output) decreased to just over 85%. Projects where one or two pairs of collaborators had previously worked together had an expected probability of peer-reviewed output of about 10% and 30%, respectively.
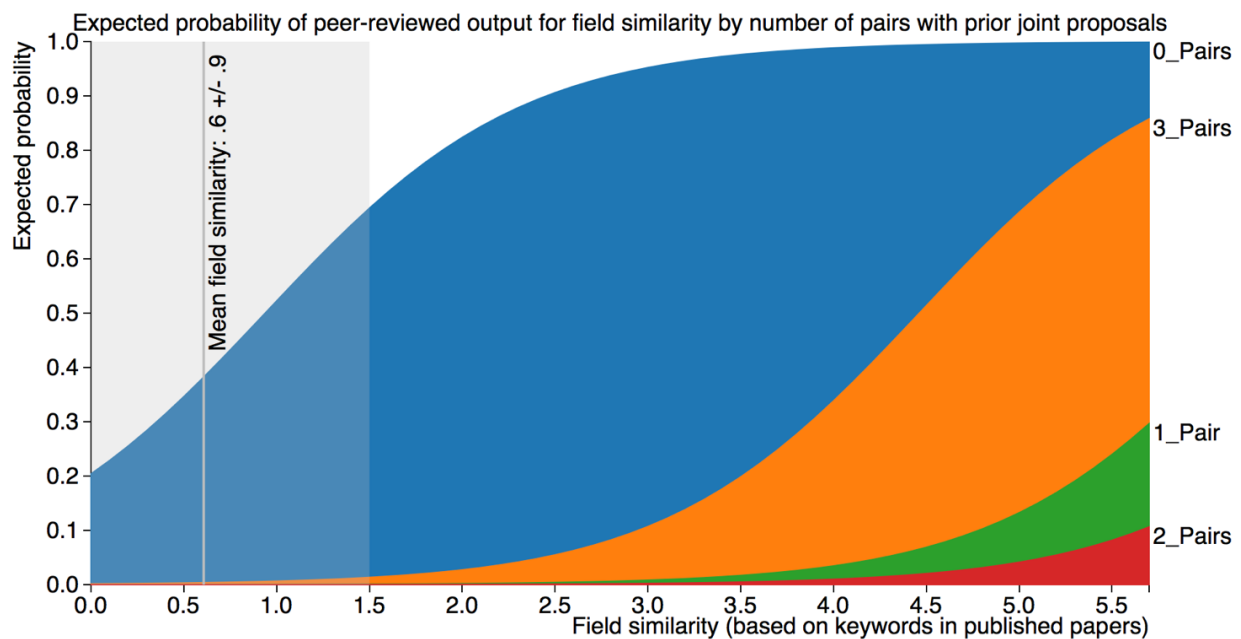
Figure 0-4: Expected probability of peer-reviewed output for field similarity by number of pairs with prior joint proposals

4.4.7 Gender results

Previous work has shown that gender imbalance, and which gender has higher representation in a team, can both influence creative output (Bell et al., 2011). The only differences in the gender composition of a group appeared when looking at peer-reviewed output. Gender did not have an effect on lightly reviewed or non-reviewed/informal output. The difference between projects composed of three women and projects composed of three men was

not statistically significant. In contrast, projects with a mix of genders were statistically different in the positive direction from projects with only male participants.

Holding all other variables constant, having one woman on a project increased the odds of producing a peer-reviewed publication by a factor of 270.5. Having two women on the project team also increased the odds of producing a peer-reviewed publication, this time by a factor of 36.8, again holding all other variables constant. In Figure 4-5, the red curve is the same as the graph shown in Figure 4-3, which reflects a project with all male collaborators. As Figure 4-5 shows, the expected probability of a peer-reviewed publication from a project with the mean field similarity was just under 40%, holding all other variables at their base or mean as appropriate. Projects with a mean field similarity score and one woman had an almost 100% expected probability of peer-reviewed publication. Projects with a mean field similarity score and two women had an over 95% expected probability of peer-reviewed publication. These results directly support previous research that shows a positive correlation between gender mix and the creative output of a team.
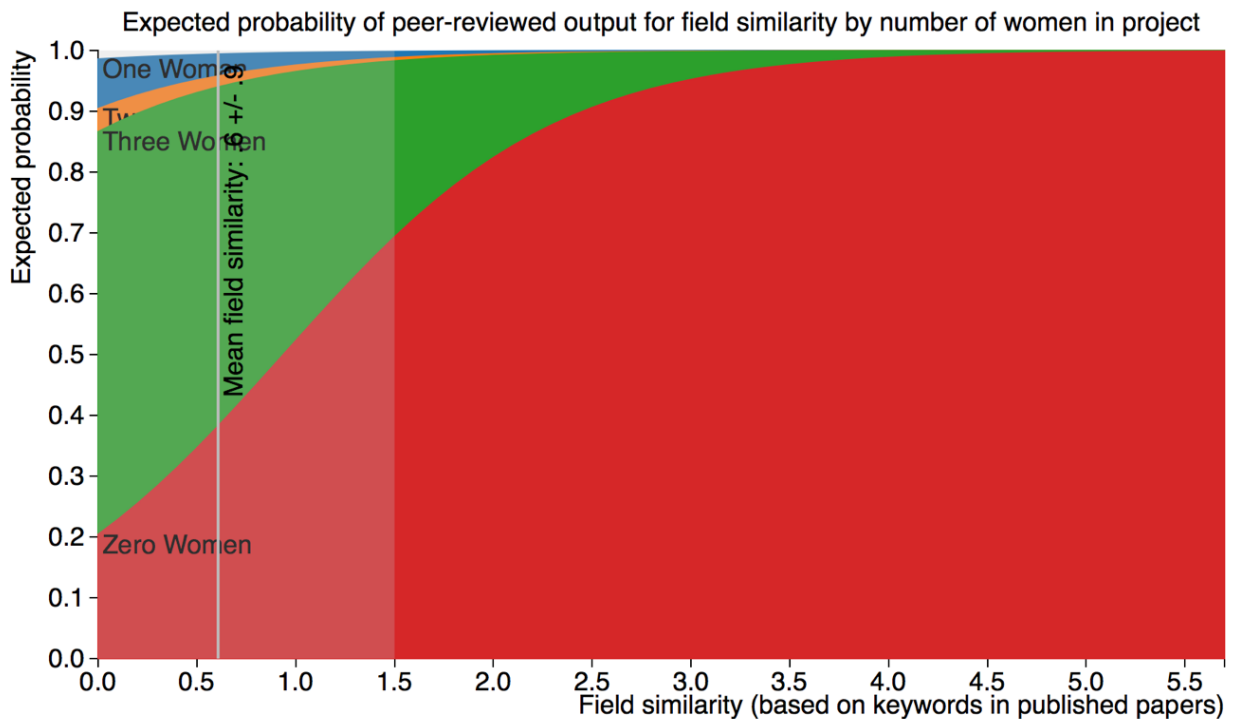
Figure 0-5: Expected probability of peer-reviewed output for field similarity by number of women in a project.

4.4.8 Ethnicity/race results

There are conflicting theories on the effect of ethnic diversity on teams (Bell et al., 2011; Freeman & Huang, 2014). The only statistically significant differences in the ethnic diversity of a group appeared when looking at peer-reviewed output. Ethnic diversity did not have an effect on lightly-reviewed or non-reviewed/informal output. The results in this analysis show that a mix of races and ethnicity increased the odds of producing a peer-reviewed publication by a factor of 64.3, holding all other variables constant. In Figure 6, the orange curve is the same as the graph shown in Figure 4-3, which reflects a project where all collaborators were of the same ethnicity. As Figure 4-6 shows, the expected probability of a peer-reviewed publication from a project with the mean field similarity was just under 40%, holding all other variables at their base or mean as appropriate. Projects with a mean field similarity score and an ethnic mix had just under a 100% expected probability of peer-reviewed publication. These results support research that suggests that ethnic diversity has a positive effect on teams.
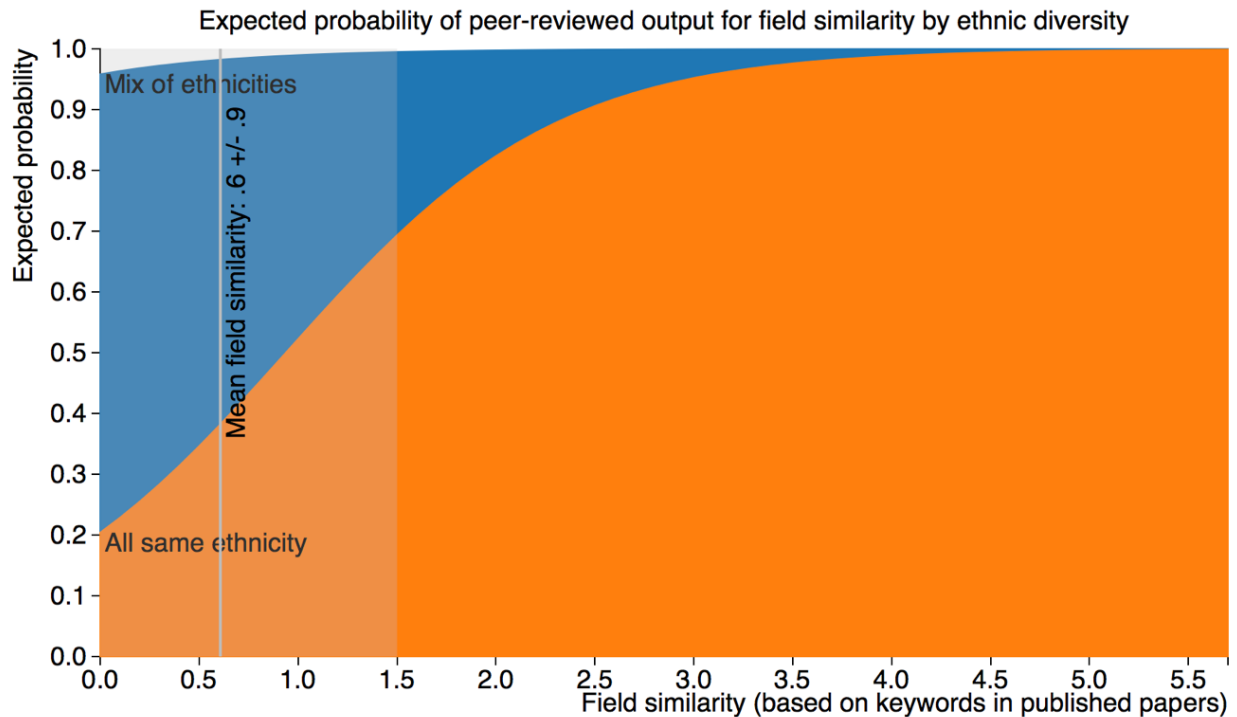
Figure 0-6: Expected probability of peer-reviewed output for field similarity by ethnic diversity

4.4.9 Rank/tenure results

Multiple research studies suggest that an increased proportion of tenured faculty members in a project will be associated with increased creative output (Cummings & Kiesler,

127

2008; Phelps et al., 2012). When looking at peer-reviewed output, the difference between projects with two tenured faculty members was not significantly different from teams with no tenured faculty members. In contrast, when looking at lightly-reviewed output, having one or three tenured faculty members was no different, statistically speaking, from having no tenured faculty members. Tenure did not have a statistically significant impact on non-reviewed/informal output.

Projects with one tenured faculty member and three tenured faculty members did have a statistically significant negative effect on the odds of producing a peer-reviewed publication. In Figure 7, the blue curve is the same as the graph shown in Figure 4-3, which reflects a project with all non-tenured collaborators. As Figure 4-7 shows, projects with a mean field similarity score and three tenured faculty members have about a 5% expected probability of producing a peer-reviewed publication. This effect was minimized when projects had the highest levels of field similarity, with an expected probability of just under 95%. Projects with one tenured faculty saw the most effect on the probability of producing a peer-reviewed publication. At the mean degree of field similarity, the expected probability of producing a peer-reviewed publication was essentially zero. Even at the maximum field similarity, the expected probability was under 20%. These results slightly contradict theories which state that more experience, operationalized as tenure, results in higher levels of creative output.
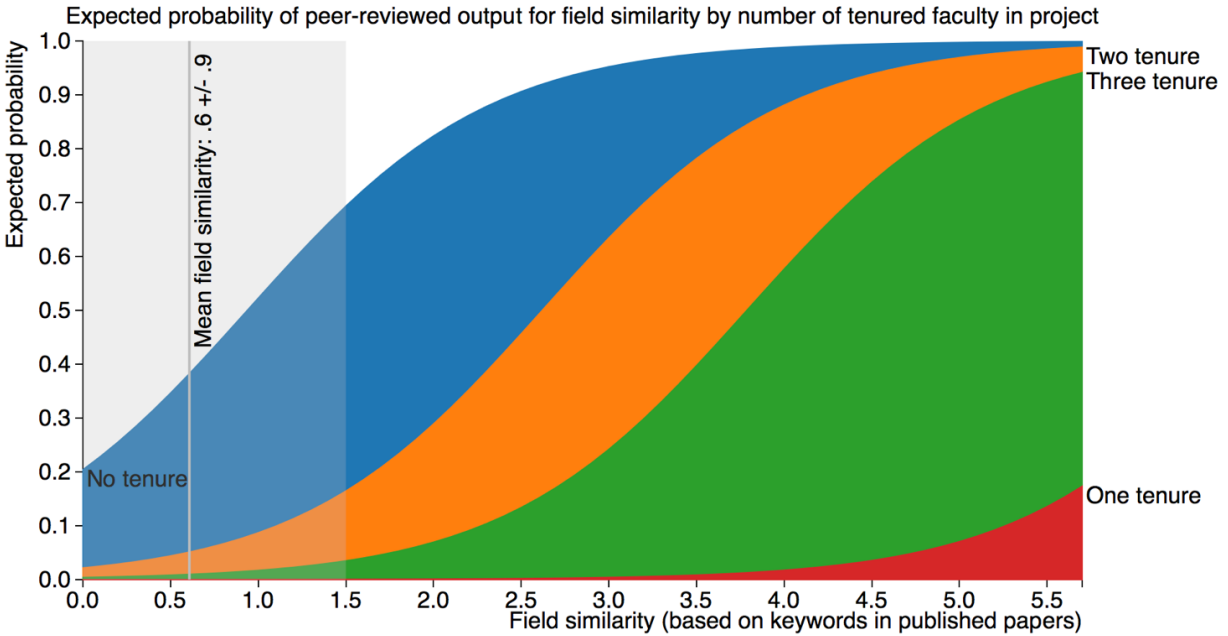
Figure 0-7: Expected probability of peer-reviewed publication for field similarity by number of tenured faculty in a project

Projects with two tenured faculty members had a statistically significant positive effect on the odds of producing lightly-reviewed output. Holding all other variables constant, having two tenured faculty members on a project increased the odds of producing lightly-reviewed output by a factor of 6.759. In Figure 4-8, the red curve is the base case, representing a project with all non-tenured collaborators. As Figure 4-8 shows, projects with a mean field similarity score and no tenured faculty members had about a 15% expected probability of producing a peer-reviewed publication. In contrast, projects with two tenured faculty had just over 40% expected probability of producing lightly-reviewed output at the mean degree of field similarity.
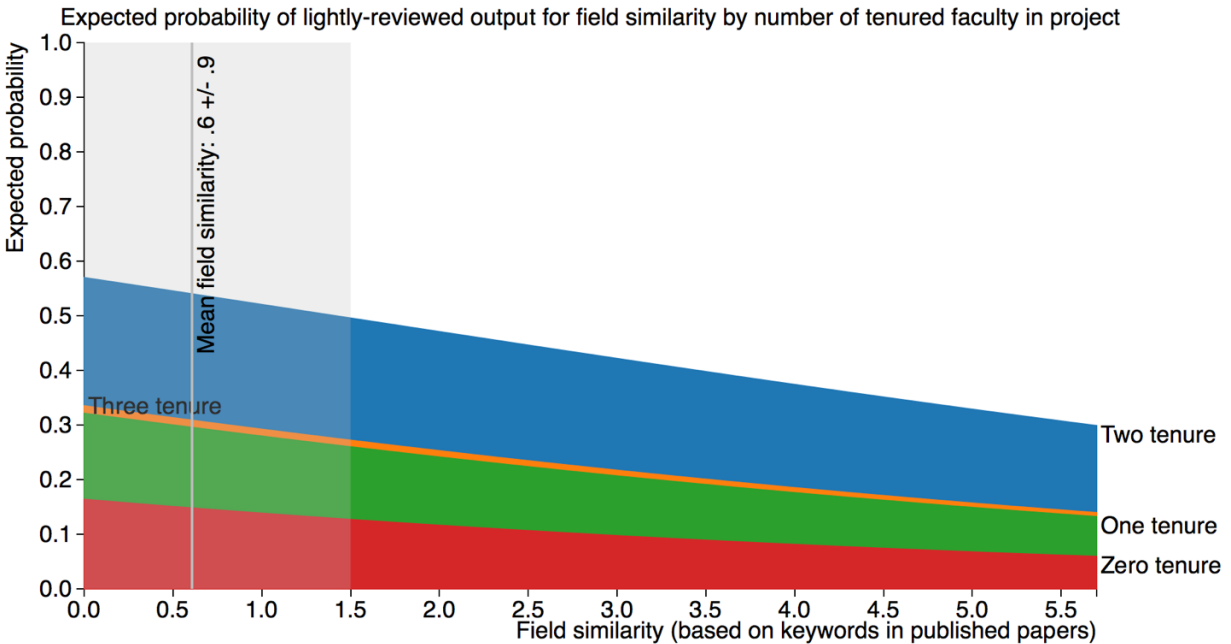
Figure 0-8: Expected probability of lightly-reviewed output for field similarity by number of tenured faculty in a project

4.4.10 Group coordination

I hypothesized that the use of coordination tools, such as shared databases or file sharing services, would be associated with increased creative output (Cummings, 2005; Cummings & Kiesler, 2007a; 2008). The support for this hypothesis varied, depending on the type of output. In all types of output, cloud-based applications (i.e., Google Docs), intranets, and other miscellaneous types of coordination tools did not have a statistically significant effect on the likelihood of producing any type of output.

This hypothesis was not supported when examining peer-reviewed output. While the use of shared databases had a statistically significant effect, that effect was in the opposite direction from the hypothesis. In fact, shared databases decreased the likelihood of producing a peer-reviewed publication by a factor of .066. In Figure 4-9, the blue curve is the same as the graph shown in Figure 3, which reflects a project where project collaborators did not use any coordination tools. As Figure 4-9 shows, projects with a mean field similarity score and using a shared database had just under 5% expected probability of producing a peer-reviewed publication, compared to just under 40% expected probability when using no coordination tools.

Figure 0-9: Expected probability of peer-reviewed output for field similarity by using a shared database

The hypothesis that the use of coordination tools would be associated with increased creative output was partially supported when examining lightly-reviewed and non-reviewed/informal output. Using shared file repositories—either cloud-based or local file servers—increased the odds of producing lightly-reviewed output by a factor of 6.811. In Figure 4-10, the orange curve is the base case, representing a project using no coordination tools. As Figure 4-10 shows, projects with a mean field similarity score and no coordination tools had about a 15% expected probability of producing lightly-reviewed output. In contrast, projects that used shared file repositories had about a 55% expected probability of producing lightly-reviewed output at the mean degree of field similarity.
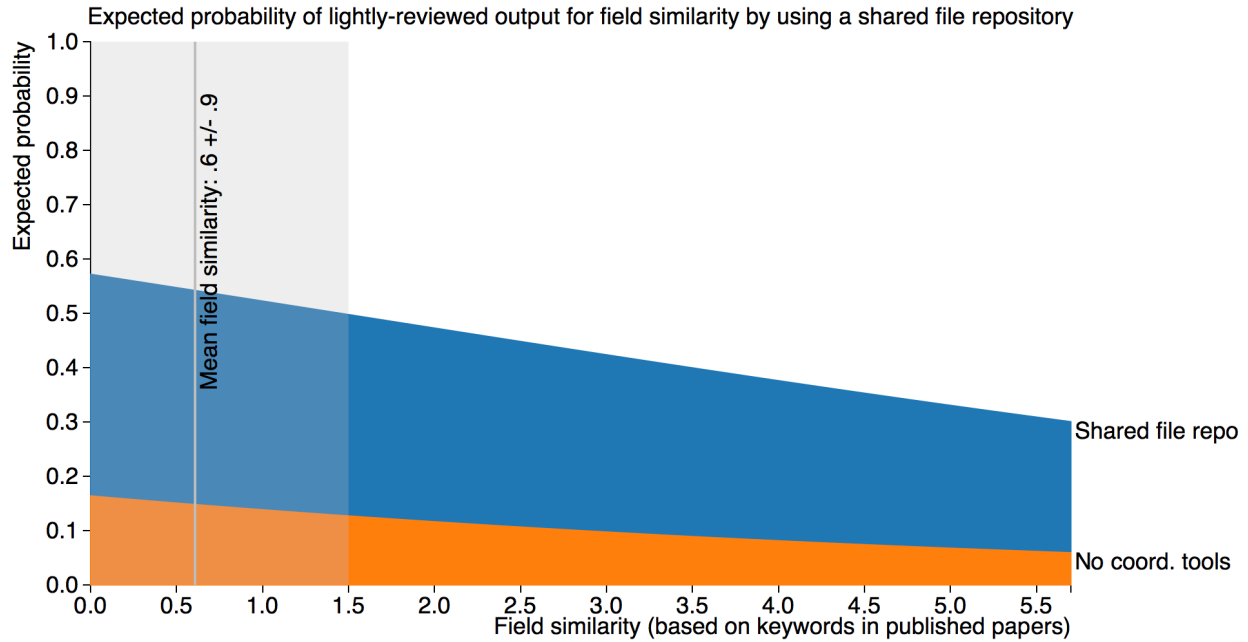
Figure 0-10: Expected probability of lightly-reviewed output for field similarity by using a shared file repository

Shared-file repositories also increased the odds of producing non-reviewed/informal output by a factor of 7.400. In Figure 4-11, the orange curve is the base case, representing a project using no coordination tools. As Figure 4-11 shows, projects with a mean field similarity score and no coordination tools had just over a 50% expected probability of producing non-reviewed output. In contrast, projects that used shared file repositories had nearly a 90% expected probability of producing non-reviewed output at the mean degree of field similarity.
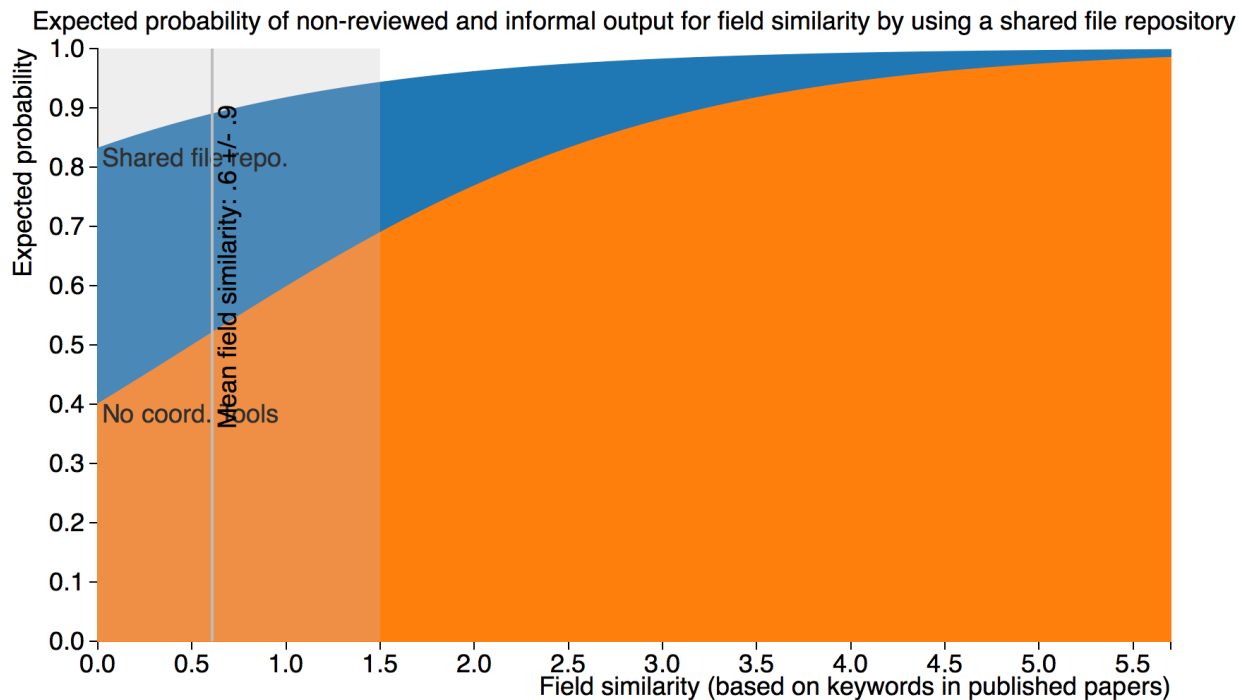
Figure 0-11: Expected probability of non-reviewed and informal output for field similarity by using a shared file repository

4.4.11 Prior output

Finally, I hypothesized that prior creative output would increase the chances of later output, because the prior output would give valuable feedback. I was only able to test this hypothesis on peer-reviewed output. The support for this hypothesis varied. Lightly-reviewed prior output had a statistically significant positive effect on the likelihood of producing peer-reviewed output. Non-reviewed or informal output did not have a statistically significant effect on the likelihood of producing peer-reviewed output. Having prior lightly-reviewed output increased the likelihood of producing peer-reviewed output by a factor of 89.645. In Figure 4-12, the orange curve is the same as the graph shown in Figure 4-3, which reflects a project where project collaborators did not have any prior lightly-reviewed output. As Figure 4-12 shows, projects with a mean field similarity score and prior lightly-reviewed output had nearly a 100% expected probability of producing a peer-reviewed publication, compared to just under 40% expected probability for no prior lightly-reviewed output.
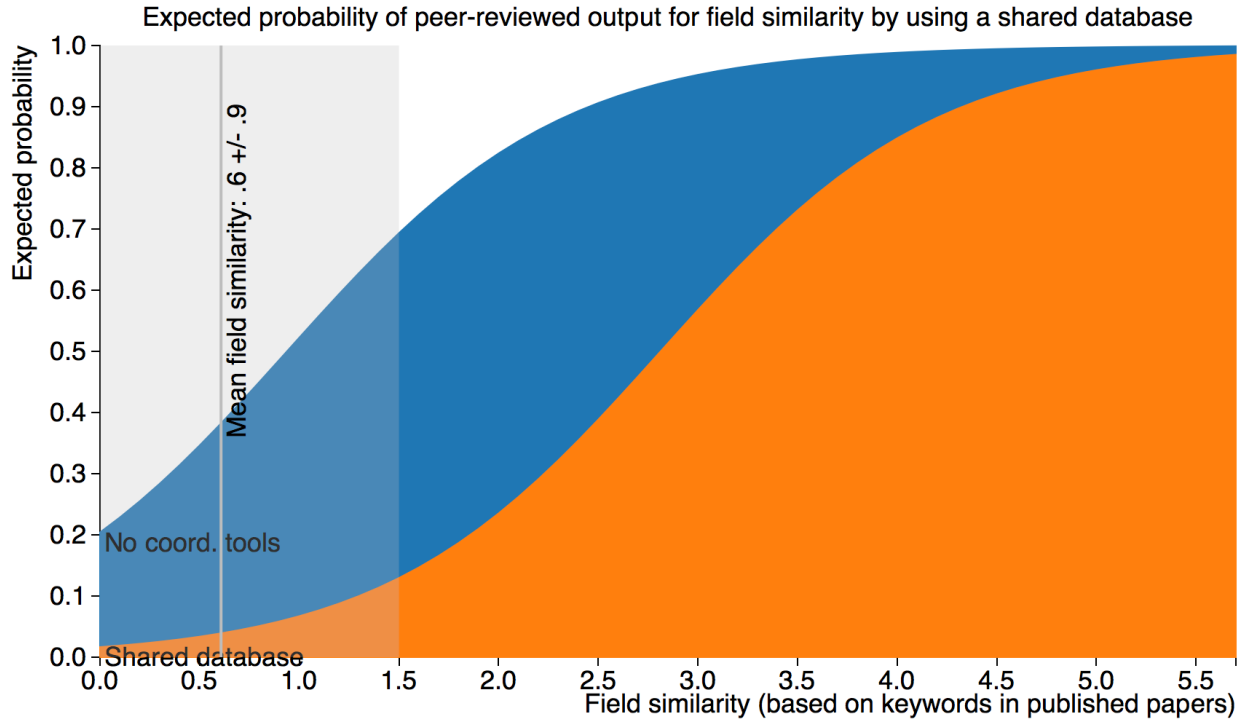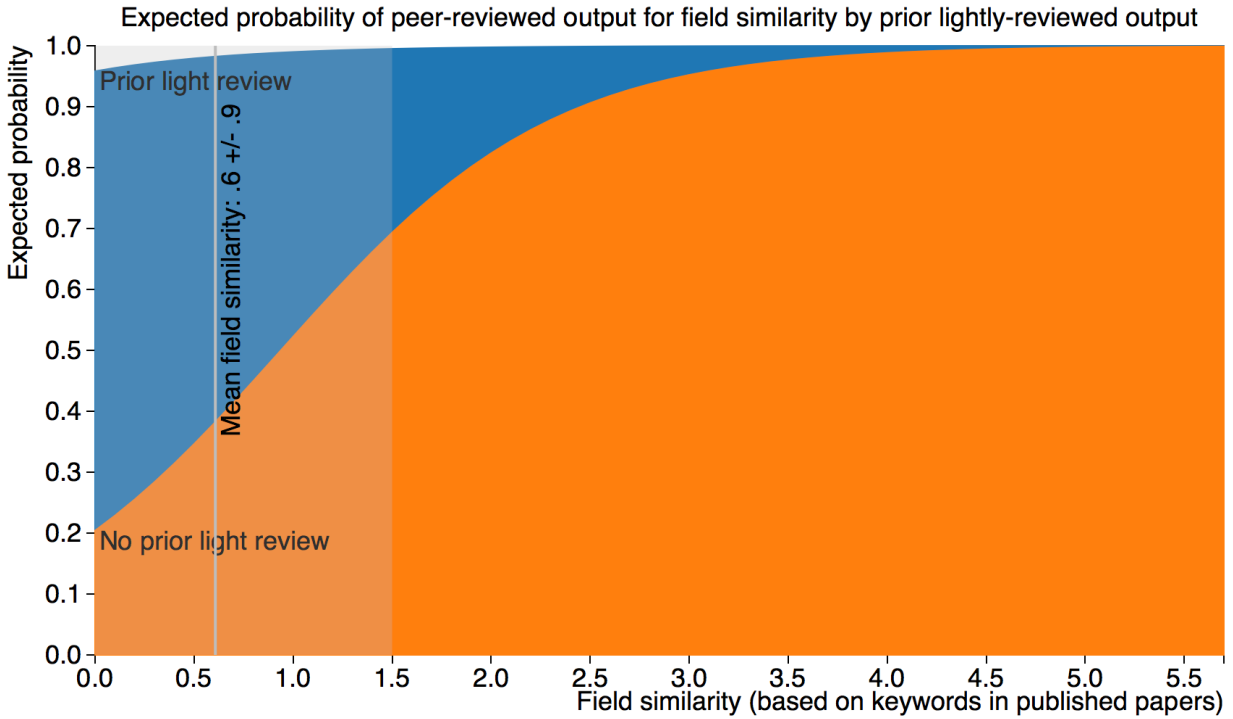
Figure 0-12: Expected probability of peer-reviewed output for field similarity by prior lightly-reviewed output

4.5 Discussion

There were a number of surprising results in the models presented above. Some were as simple as non-significant control variables, such as the relative publishing speed. Others appeared to contradict prior research on the subject; specifically, the number of tenured professors on a project, the number of pairs of collaborators with joint proposals, and the use of coordination tools. I included variables that were correlated to the various types of research outputs defined in Chapter 3.

4.5.1 Comparison of publication probabilities

While these results are interesting, the next question is, how do these numbers compare? In 2010, the National Science Foundation published a working paper that analyzed the relationship between research inputs such as federal funds and research outputs, specifically publications (Javitz et al., 2010). The NSF reported that for every additional $1 million spent on academic research, there were an additional 3.3 to 4.8 journal articles published by an institution receiving federal research funding (Javitz et al., 2010).

While this is not a direct comparison to the MCubed program, it does provide a starting point for thinking about academic productivity. Not including the costs of administering the MCubed initiative, a total of $13,320,000 was spent on the 222 research projects, each of which received $60,000. There are two issues here. The first issue is that federal research dollars are spent on direct research costs, such as paying graduate student salaries, and indirect research costs, such as maintenance for university facilities. MCubed funds went entirely to direct research costs. According to the U-M Office of Research and Sponsored Projects, indirect costs are equal to 55% of the direct research costs (http://orsp.umich.edu/indirect-costs-rates). This means that the money spent on MCubed must include an additional 55% to make the federal and MCubed dollars spent comparable. If the indirect costs are included, U-M spent $20,646,000 on MCubed.

A total of 90 MCubed projects produced peer-reviewed output, for an average of 4.4 peer-reviewed outputs per $1 million spent on MCubed. This brings up the second issue: comparing MCubed to federal funds. The NSF study only included published journal articles listed in the Thomson ISI Science and Social Science Citation Index (Javitz et al., 2010). In contrast, I counted any article published in any peer-reviewed publication venue, as well as books, neither of which would be listed in the ISI Citation Index. I also included peer-reviewed outputs that were not publications, such as art exhibitions. This means the MCubed average of 4.4 peer-reviewed outputs per $1 million spent is somewhat inflated compared to the NSF number. Despite these limitations, this comparison does give a reasonable starting point for thinking about the numbers presented in this analysis.

4.5.2 Demographic diversity

The results of the analysis support previous research indicating that demographic diversity is beneficial. In fact, demographic diversity had a strong, statistically significant effect across all versions of the peer-reviewed model. This effect only grew in size and statistical significance as more variables were added to the model.

Previous research suggests that people with the same ethnicity are more likely to collaborate, but that the collaborations produce less impactful research (Freeman & Huang, 2014). Other research contradicts this finding, arguing that an ethnically mixed team is less likely to produce creative output (Bell et al., 2011). The significance and strength of the ethnic mix

135

variable in this analysis indicates that the different cultural perspectives represented by ethnicity were a positive benefit to producing peer-reviewed output.

Gender diversity performed slightly differently than ethnic diversity. Gender diversity was not quite significant by itself, but by the time all the independent variables were added, it had a strong and significant positive effect. All-woman teams were only marginally significantly different from all-men teams, although they did approach statistical significance. This could indicate that an all-female team would have been significantly different from an all-male team if different considerations were included in the models. Overall, a mix of genders was more effective at generating peer-reviewed publications than teams with one gender.

As a test, I re-ran the peer-reviewed logistic regression with one woman as the reference category instead of no women. In this test, the two-women category was not statistically significantly different than the one woman category. The no-women category was statistically significantly different at the $p < .05$ level, with a negative effect. The three-women category was statistically significantly different at the $p < .01$ level, with the largest negative magnitude. These findings could indicate that mixed gender teams are more effective than teams with a single gender. Future work would be necessary to confirm this hypothesis.

The results could also be explained by the gender distribution in various fields. In 2006, only 11% of tenure-track faculty in Engineering were women, compared to 46% in Psychology (Burrellli, 2008). While these two fields represent the extremes, these numbers depict a trend. Women made up about 17% of tenure track faculty in mathematics and the physical sciences, and 32% and 34% of tenure-track faculty in the life and social sciences, respectively (Burrellli, 2008). Women made up 21% of tenure-track faculty in computer science (Burrellli, 2008). Future work would need to take field into account and separate the effect of gender from field.

The strength of the effect of diversity in terms of ethnicity and gender gives more fuel to the recent argument in science for bringing more women and minorities into the fields of Science, Technology, Engineering, and Math (STEM). It also supports the argument for different perspectives in collaborations. Interestingly, previous research suggests that women and minorities tend to prefer projects that address larger societal problems, and these often require an interdisciplinary approach (Rhoten & Pfirman, 2007). The strong positive effect of mixed demographic teams suggests that bringing more women and minorities into STEM fields could do more to address larger societal problems and also result in more progress toward those goals.

136

4.5.3 Tenure

Previous research suggests that depth of knowledge and experience in a given field of study tends to increase creative output (Cummings & Kiesler, 2008; Phelps et al., 2012). The results of this study show mixed results for this theory. Having one or three tenured faculty members on a project had a small negative impact on peer-reviewed publications, but having two tenured professors on a project increased the likelihood of lightly-reviewed output.

These seemingly contradictory results may be an effect of the tenure process. Peer-reviewed publications are heavily weighted in tenure cases, and assistant professors need peer-reviewed publications to secure tenure. While peer-reviewed publications are still important after tenure has been secured, tenured professors have more flexibility in how they spend their time. Also, tenured professors have more freedom to explore interests outside their core area. For example, a tenured professor could work to complete an online archive and wait until the archive is finished to publish articles about the contents of the archive.

The reduced pressure to publish could also account for the increased likelihood to produce lightly-reviewed output. Conferences provide two useful benefits. First, researchers can get feedback on research prior to submitting their work to a peer-reviewed venue, which could improve the quality of the final manuscript, thereby increasing the chances of peer-reviewed publication. Second, conferences provide an opportunity to interact with colleagues. However, submitting to a lightly-reviewed venue could also increase the time needed to submit the manuscript to a peer-reviewed venue. This extra time may discourage researchers who are attempting to get tenure from submitting to lightly-reviewed conferences, because they do not count toward a tenure case.

4.5.4 Prior interactions

One surprising result was the small negative effect prior joint proposals had on the likelihood of peer-reviewed publications. A large body of research demonstrates the positive effect of prior association on the success of collaborations (Birnholtz, 2007; Cummings & Kiesler, 2007b; Gardner et al., 2012; Hara et al., 2003; Hemlin, 2009; Melin, 2000; Phelps et al., 2012; Schunn et al., 2002; Shrum et al., 2001). There are a few possible explanations for these counter-intuitive results.

First, it may be that the collaborators are focusing on producing another proposal based on the results of their MCubed project. This theory is partially supported by the fact that 87.5% of projects with three pairs of collaborators with prior proposals reported preparing or submitting a proposal for further funding (Traugott et al., 2015). Producing a proposal to further support a research project, and producing a manuscript to submit to a peer-reviewed venue, both take a significant investment of time and effort. Funded proposals are also quite important to the tenure process, and they often cover a professor's salary during the summer months. This double impact of successful proposals could mean that proposals take a higher priority over peer-reviewed publications. Additionally, those who have generated successful proposals in the past are probably more likely to produce successful proposals in the future.

4.5.5 Field similarity/diversity

Field similarity had a positive and statistically significant effect on the likelihood of peer-reviewed output, as hypothesized. This was seen despite the inherently messy nature of the data, due to name disambiguation. In tests where name disambiguation was not an issue, the project collaborator similarity scores were even higher.

As mentioned earlier, teams that have similar backgrounds also have the same type of jargon, as well as similar data collection and analysis methods. This reduces the time it takes to agree on how to approach a problem. It is possible that the effect of field similarity will decrease as time passes, so that project collaborators who need more time to agree on approaching their selected problem will start to produce results. This might also explain why field similarity did not show a strong effect on the lightly-reviewed and non-reviewed/informal models.

4.5.6 Differences in institutional support

While this hypothesis was confirmed, differences in institutional support did not become statistically significant in the peer-reviewed model until the last variable—prior lightly-reviewed output—was added. This indicates that the level of organizational support for interdisciplinary collaboration is influenced by other factors. This particular variable was operationalized as the difference in collaborators' units' support for MCubed. I felt this was a reasonable proxy for the degree of institutional support for interdisciplinary collaboration, because MCubed was an experiment in encouraging interdisciplinary collaboration. This reasoning was supported by the fact that all U-M units participated in MCubed, although with different levels of support.

Because amount-of-unit-investment was used, this variable could be more a reflection of the difference in the amount of money different U-M schools and colleges have to spend on experimental programs.

4.5.7 Group coordination

Similar to prior experience working together, there is an extensive body of literature describing the importance of effective coordination to collaboration (Cummings & Kiesler, 2007b; 2008; Hernandez, 2012; Newman, 2001; Schunn et al., 2002; Velden & Lagoze, 2012b). Like tenure, the results of using coordination tools was mixed. Some coordination tools, specifically databases, were associated with a lower likelihood of producing a peer-reviewed publication, and others were associated with a higher likelihood of other types of scholarly output; specifically, shared-file repositories.

The findings regarding shared-file repositories are not particularly surprising. The ability to work from the same file can save significant time. There is no need to spend extra time integrating changes because the changes are made right to the file, whether that file consists of data, or is a manuscript. Although there can be a few extra coordination costs associated with a shared-file repository, they can usually be overcome with a variety of strategies. The bigger question is why shared repositories were not significant in the models that examined peer-reviewed output. It may be that some basic strategies to avoid file conflicts that work well in the earlier stages of a project may not work as well in the later stages of a project. For example, an increased chance of conflicting file copies exists if multiple authors need to perform final edits to a manuscript just prior to submission to a peer-reviewed venue—which then need to be resolved.

At first glance, the results regarding shared databases seem to at least partly contradict earlier research, but the results make sense when considered more deeply. First, databases typically require more specialized knowledge to use than other common tools such as Excel. The project could be slowed down if only one researcher on the team has that specialized knowledge, and the other researchers rely on that person to extract information from the database. Second, a research project that generates enough complex data to require a database is probably more complicated, which could prolong the publication of a peer-reviewed paper

4.5.8 Prior output

Publishing research output in a lightly-reviewed venue can be beneficial, giving researchers an opportunity to get feedback before submitting their research to a peer-reviewed venue. First, researchers obtain feedback from those who are reviewing their submission. While the reviews from a lightly-reviewed venue are not as detailed as the feedback for a peer-reviewed venue, they do help to provide some high-level guidance—by pointing out places where the authors need to either provide more details, or areas where the authors need to dig deeper. Once the research is accepted to a lightly-reviewed venue (e.g., a conference) the researchers can get more feedback from conference attendees.

Additionally, some lightly-reviewed conferences will select the best papers and publish them in a special issue of a journal. In these cases, the paper gets two rounds of peer-review. The first round gets the paper into the conference, and the second round fleshes out the conference paper into a full journal article. Whether or not this occurs, the feedback obtained by the researchers in this process results in a more polished and higher quality manuscript that is more likely to be published in a peer-reviewed venue.

4.6 Conclusion

The results of this analysis provide mixed support for the impact of diversity on the output of an interdisciplinary collaboration. Demographic diversity—gender and ethnic diversity—increased the chances of peer-reviewed output from a project. On the other hand, projects with higher degrees of field similarity were more likely to have peer-reviewed output. Similarity in institutional support had a small negative effect on peer-reviewed publication. Perhaps the most surprising result was that projects where collaborators had prior joint proposals were dramatically less likely to have peer-reviewed publications. Finally, shared file repositories increased the likelihood of lightly-reviewed and non-reviewed/informal output.

A caveat—which applies to all of the results—is that some projects may not have had sufficient time to produce peer-reviewed output. To confirm these results, any new study should examine project output in another three to five years, which would identify new publications to come out of these projects since the time the data for this analysis were collected. Other future work should refine the field publication parameter to make it more fine-grained, which could

have an impact on the results found in each of the models. A more complete discussion of limitations and future work is presented in the next chapter.

This chapter attempted to shed light on most of the questions raised in Chapter 1 regarding interdisciplinary collaboration. The first question is whether the institutional environment is supportive. Differences in departmental support for interdisciplinary collaboration, as operationalized, did have a negative effect on the output of those interdisciplinary research projects. Theoretically, researchers with prior joint proposals were already familiar with each others' working styles—because they had already worked together on funded research projects—thereby reducing the need for time-consuming and potentially adversarial conversations about which theoretical models and methods to use. Finally, there is the central question of whether interdisciplinary collaboration is truly beneficial. The results suggest that increased disciplinary similarity is actually beneficial. In the next chapter, I go deeper into all of the questions raised in Chapter 1, and discuss how the results of this and the previous chapters provide insight into the answers to those questions.

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143

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Chapter 5

Discussion / Conclusion

5.1 Introduction

In this chapter and throughout the dissertation, I have explored various aspects of the MCubed program and the projects that were funded through it. The levels of analysis ranged from individual investigators up to the MCubed program itself. In Chapter 1, I posed a number of questions regarding the MCubed program: (1) Can researchers who want to collaborate find collaborators? (2) Is the institutional environment surrounding an interdisciplinary collaboration supportive? (3) Is interdisciplinary collaboration beneficial, considering the challenges posed by the first two questions?

Each of the chapters addressed at least two of the research questions posed in Chapter 1, and provided answers to those questions in the context of the MCubed initiative. In Chapter 2, I established that most researchers found their collaborators through their own personal and professional networks, rather than through the MCubed website. In Chapters 2 and 4, I found that prior interactions, rather than project output—in particular, working together on previous research projects—were most important for project formation. The findings from all three chapters suggested that a supportive institutional environment was critical for both project formation and output. Finally, findings from Chapters 3 and 4 suggested that the potential benefits of interdisciplinary collaboration were a matter of institutional perception and the degree of interdisciplinarity represented in a project.

Chapter 2 attempted to answer questions (1) and (2) by first looking at how the institutional environment affected the formation of interdisciplinary collaborations, and then

149

focusing more tightly on how researchers found collaborators. I accomplished this by studying two aspects of MCubed: the MCubed website and the evolution of the MCubed funding process. This allowed me to understand how those aspects central to MCubed affected unit participation and project formation.

Institutional support for interdisciplinary collaboration can take many forms. Chapter 2 looked at just one aspect of that support. In Chapter 3, I concentrated on a different aspect: publication venues for project output. I focused more tightly on the individuals who were funded through MCubed; particularly, what types of research output they typically created over the course of their careers. This emphasis on project output venues is intimately connected to the last question raised in Chapter 1, which related to the benefits of interdisciplinary collaboration. Essentially, these venues judge whether a specific audience would view the output of the MCubed collaborations as beneficial. This led to the creation of the Scholary Arc, which accounts for all outputs from a research or creative project, rather than just the final peer-reviewed output.

Chapter 4 brought together two of the questions introduced in Chapter 1. The overall goal was to understand how the institutional environment and prior experience working on funded research combined to make interdisciplinary collaboration work more smoothly, thereby increasing the likelihood of beneficial outcomes. I focused on funded MCubed projects through the lens of the output of those projects as represented by the Scholarly Arc. This allowed me to understand how team composition along a number of dimensions, and coordination mechanisms within that team, affected the project's creative output.

The goal of this final chapter is to pull together the common threads in the previous chapters. First, I will focus on the questions posed in Chapter 1, and how the findings in each of the chapters answer those questions. Next, I look at some of the larger issues encompassing the questions introduced in Chapter 1. Finally, I suggest directions for future work.

5.2   Questions Regarding Interdisciplinary Collaboration

Many argue for the potential benefits of interdisciplinary collaboration (e.g., Page, 2007; Reiter-Palmon, Ben Wigert, & de Vreede, 2011). But others question whether the potential benefits of interdisciplinary collaboration outweigh the difficulties of participating in this type of research (e.g., Bell, Villado, Lukasik, Belau, & Briggs, 2011; Schleyer, Butler, Song, & Spallek,

2012). In the following section, I explore these open questions through the findings of the previous three chapters.

5.2.1 Can those who want to collaborate find collaborators?

One of the primary goals of MCubed was to encourage U-M researchers to explore new collaborations with researchers from different departments. The MCubed website was intended as one of the primary tools to help researchers at U-M find collaborators outside their disciplines. While some managed to find new collaborators this way, the findings from Chapters 2 and 4 suggest that this was the exception rather than the rule.

About a third of the filled MCubed projects were formed in less than a day. Another 17% of projects were filled in two or three days. This quick formation suggests that all of the arrangements for the projects were made before the project was even posted on the MCubed website. Additionally, just over 40% of funded token holders did not extensively use the site prior to committing their token to a project. Again, this suggests that these researchers were not using the MCubed website to find their collaborators.

If the MCubed researchers did not find their collaborators through the MCubed website, how did they find collaborators? There are a few potential answers to this question. First, the majority of filled MCubed projects were composed of collaborators from two different units, indicating that many of the collaborators from the two-unit projects knew each other prior to their participation in MCubed. In about 40% of the projects, at least one pair of collaborators had a prior joint proposal. These researchers not only knew each other prior to collaborating on the MCubed projects, but they had worked together as well.

Previous studies have suggested that researchers tend to work with people they know through other means: through a mutual collaborator, someone from their own department, or someone they have worked with previously (Bozeman & Corley, 2004; Kraut, Galegher, & Egido, 1986; Newman, 2001; Owen-Smith, Kabo, Levenstein, Price, & Davis, 2012). These findings suggest that all of those factors came into play when MCubed token holders decided to find a collaborator.

5.2.2 Is the institutional environment supportive?

All the chapters in this study touched on this question. In Chapter 2, the focus was on the university department of the MCubed collaborators. Chapter 3 touched on both the department's

and the larger discipline's support for research that produces non-traditional outputs. Chapter 4 looked at how differences in departmental support affected the outcomes of funded MCubed projects. Where Chapter 3 covered what types of output were typical for a given U-M unit, the effect of departmental support was most visible in Chapters 2 and 4.

Judging by the large differences between the number of tokens distributed and the maximum number funded in each participating U-M school, college, or department, it is probably safe to say that there was a large difference in the institutional support by different units. In some departments, this difference was probably due more to a basic lack of funds rather than a lack of support for interdisciplinary collaboration in general. Departments experiencing funding limitations included Education, Art & Design (A&D), and Music, Theatre & Dance (MT&D). These units all had a small maximum number of available funding tokens, and more researchers seeking those limited funds. In these cases, one must look beyond the immediate department to the larger institutional environment that makes funds available for these creative and scholarly endeavors.

The diversity in units and fields created a large diversity of project outputs. Journal articles and conference presentations were the most common. About 80% of project collaborators reported either planning an article, or had already published one, and about 75% of project collaborators reported either planning a conference paper, or had already presented one. On the other hand, almost 21% of projects reported a performance as one of the project outcomes, and almost 7% reported an exhibition. The goal of this study was to go beyond the typical project outputs—such as journal or conference publications—and include all potential project outputs. While my goal was to be as inclusive as possible, many departments take a much more exclusive view of research output. Some journals or conferences are much more valued than others, even within a given field. Research outputs that do not fall into these departmental boxes are often viewed as a waste of time and resources.

The "Jeweled Net of the Vast Invisible" is one example of a highly successful and popular project. This collaboration between an astrophysicist, a musician, and an artist resulted in an immersive multimedia installation and multiple recordings. While those outputs were perfectly acceptable for the musician and the artist, they would not mean much to an astrophysics department. It is worth noting that the astrophysicist is a full professor who did not need to worry about getting tenure. While this project certainly had the desirable outcome of bringing the

general ideas of astrophysics to a wider audience, it did not advance the state of the art in that field. It would not have held much weight in a tenure case if the researcher did not have enough academic publications. This project happened because the full professor in astrophysics did not have the same degree of need for departmental support as would an assistant professor.

The effect of tenure on project output continued to be seen in Chapter 4. Having one tenured faculty member or three tenured faculty members decreased the chances of producing a peer-reviewed publication, as compared to no tenured faculty on a project. Having two tenured faculty members on a project increased the chances of producing a lightly-reviewed research output. Essentially, the department and the university have granted the necessary institutional support for wider exploration. The message to assistant professors is that they must earn the institutional support necessary to explore new ideas: less than 10% of projects had no tenured faculty members. Although tenured faculty members were not required for MCubed projects, the numbers suggest the benefits of including a member who had already earned the implied institutional support granted by tenure.

Chapter 4 also showed that projects with collaborators from units with roughly similar attitudes toward interdisciplinary collaboration—operationalized as roughly equal levels of support for MCubed—were more likely to have produced peer-reviewed publications. If all the collaborators came from units with high levels of support, that support probably helped to make the projects more likely to publish. On the other side, if all of the collaborators' units had low levels of support for interdisciplinary collaboration, the collaborators were probably used to dealing with departmental barriers to collaborative research, and they could help each other to find ways around the barriers. The problem was in the middle. If one collaborator came from a unit with not much support for collaborative research, and the other two came from a unit with a high level of support for collaborative research, the ones with high levels of support might not have been able to advise their colleague on overcoming those barriers.

The findings from this study indicate that institutional support is critical at all levels for interdisciplinary collaborations. At the level of academic disciplines, venues must exist to fund interdisciplinary projects and to publish the output from that project. The output from an interdisciplinary collaboration needs to be recognized at the departmental level as well, otherwise the junior researchers participating in collaborative interdisciplinary projects risk not getting promoted or nominated for tenure.

5.2.3   Does interdisciplinary collaboration confer important benefits?

There were two aspects to this question. First, the degree to which prior interactions and coordination mechanisms could mitigate the potential problems associated with interdisciplinary research. The second aspect emphasized both the perceived and actual benefits of interdisciplinary collaboration.

5.2.3.1   Prior interactions and coordination mechanisms

Chapters 2 and 4 explored this question. Chapter 2 examined where collaborators might have interacted previously—specifically, the time projects took to form and the number of two-unit projects. These impressions were tested in Chapter 4, along with other factors that could mitigate the problems associated with interdisciplinary collaboration: field similarity, the number of units represented, prior joint proposals, and the use of coordination tools .

About 40% of the projects formed in three days or less, suggesting that the collaborators found each other through means other than the website, and that the collaborators already had some degree of prior interaction. In addition, most projects, regardless of the time they took to form, were composed of researchers from two different units. This also suggests a certain degree of pre-existing prior interaction. At the least, researchers from the same unit were familiar with similar administrative requirements. These trends would suggest that collaborators from projects that were more likely to have prior interactions would also be more likely to produce research output.

Interestingly, this did not play out in the regressions in Chapter 4. The time it took for a project to form had almost no effect on the outcomes in any model. The number of units represented in a project approached significance in the peer-reviewed model, but the effect was in the opposite direction: three-unit projects were more likely to have peer-reviewed output. The number of pairs of collaborators who had previous joint proposals had a similar effect: the results ran counter to what one would expect given that the collaborators had pre-existing common ground. Projects where none of the collaborators had a prior joint proposal were slightly more likely to produce a peer-reviewed publication. As discussed in Chapter 4, there may be other factors that account for this result.

If collaborators trust each other, open communication and coordination can mitigate many of the challenges associated with interdisciplinary collaboration. This often takes the form

of face-to-face meetings or regular communication. Technical tools are often used as a supplement to make that communication more productive. While the projects in this analysis used a variety of technical coordination tools, shared file repositories was the most effective. In many ways, this is not surprising. During meetings, especially those over video, all collaborators can look at the same file, reducing the need to explain the file contents. It also ensures that any changes made by one collaborator are reflected in the files used by the other collaborators.

Based on the findings in Chapter 2, prior interactions are most important in project formation, which goes along with prior research on interdisciplinary collaboration. Chapter 4 provides mixed support for the importance of prior interactions. Some of these contrary results may simply be the result of factors that were not accounted for in the models, such as the strong negative effect of prior joint proposals on peer-reviewed publication. Finally, some technical coordination tools, particularly shared-file repositories, can support research collaborations.

5.2.3.2 *The perceived and actual benefits of interdisciplinary collaboration*

This question was addressed in every chapter. In Chapters 2 and 3, the perceived benefits of interdisciplinary collaboration were emphasized. In Chapter 4, I explored the effect of disciplinary diversity on the outputs from an interdisciplinary collaboration. This was an attempt to step back from any single point of view and understand if there is an overall benefit, regardless of point of view.

I will start by addressing the actual observed effects of disciplinary diversity on project output. Projects with more field similarity were more likely to produce peer-reviewed publications, which seems to argue against the value of field diversity. In the peer-reviewed model, both the significance and magnitude of the effect of field diversity increased when prior outputs were added to the model. The overlap in fields and specialties—operationalized as overlap in keywords associated with peer-reviewed publications—implies an increased familiarity with common domain knowledge: theories, methods, and language (Fischer, 2001; Mauz, Peltola, Granjou, van Bommel, & Buijs, 2012; Pennington, 2008). In turn, this familiarity leads to less potential social friction when deciding how to proceed on a research project (Edwards, Mayernik, Batcheller, Bowker, & Borgman, 2011). As discussed in Chapter 4, projects with lightly-reviewed output were much more likely to produce peer-reviewed output. Those projects had to have enough preliminary results to present at a lightly-reviewed venue and

155

then use that feedback to produce a peer-reviewed publication. The corresponding increase in the significance and magnitude of disciplinary similarity implies that collaborators in these projects did not need extra time to resolve disciplinary differences. The collaborators on these projects might not have needed to agree on what constitutes high quality research because their disciplines were similar enough that discussion was not necessary.

To some degree, the benefits of interdisciplinary collaboration are a function of one's point of view. All of the major units across U-M participated in MCubed, implying that everyone at least paid lip service to the idea of encouraging interdisciplinary collaboration. The question is whether the results of interdisciplinary collaboration are truly valued. While studying CVs from every unit at U-M, it quickly became obvious that the types of scholarly output varied widely. While journal publications were common, they were not universal by any means. Units that focused on art, design, and performance were marked by a distinct lack of outputs that would be standard in most other departments. By the same token, the outputs valued by design-focused departments were almost completely absent from the CVs of researchers in more traditional departments such as Medicine or Engineering. It quickly became clear that what would be considered a very successful collaboration in one department would be considered hardly worth mentioning in another. In this sense, the benefits of interdisciplinary collaboration are all relative, making the assessment of those benefits fluid and somewhat fuzzy.

Many are starting to acknowledge that the vast difference in viewpoints can be a problem when trying to objectively assess the benefits of interdisciplinary collaboration (Lane & Bertuzzi, 2011; A. J. Nelson, 2012). The Scholarly Arc developed in Chapter 3 was an attempt to take a more objective view, by attempting to include outputs that are less common, and by examining outputs that might precede the final, polished output. With this wider viewpoint, there are mixed results to support the contention that interdisciplinary collaboration is beneficial. Although it did not quite achieve statistical significance, three-unit collaborations did improve the chances of producing some sort of peer-reviewed output, compared to two-unit collaborations. On the other hand, increased field similarity had a statistically significant effect on increasing the likelihood of peer-reviewed output. However, more units do not necessarily equal more field diversity. For example, the academic fields represented by researchers at the Life Sciences Institute probably overlap to a large degree with the academic fields represented by researchers at the Medical School, or certain departments within Natural Sciences. This observation is supported by the

156

network visualizations presented in Chapter 2, which show how the various U-M units interacted throughout the MCubed funding process.

Whether interdisciplinary collaboration confers any benefits seems to be a matter of perception, and the degree of interdisciplinary overlap. The perceived benefits depend on how one defines beneficial output, but this definition can change significantly from one academic field or department to the next. This difference in perception likely means that the overlap between fields should be significant enough so that everyone agrees what type of output is desired and beneficial. In practice, this often depends on the project goals, and where the collaborators are in their professional careers. A researcher early in his career will place more value on output that aligns with his or her department's expectations and requirements—which may not be supportive of output outside the norm in that department.

5.3   Implications for Interdisciplinary Collaboration

The smaller- to middle-sized units collaborated with a more diverse set of units than larger units that centered on traditional academic fields. For example, the School of Natural Resources and Environment (SNRE) had the highest portion of three-unit projects (see Figure 4 in Chapter 2). Although the Institute for Social Research (ISR) only funded seven tokens, ISR was connected to seven different units through those funded tokens: Medicine, Public Health, Engineering, SNRE, Architecture and Urban Planning, LSA-Natural Sciences, and LSA-Social Sciences. Architecture & Urban Planning (A&UP) was similar to ISR. For almost every token funded through A&UP (10), those tokens were connected to almost as many different units (8). Faculty from these departments were also more likely to have a wider range of output type listed on their CVs than researchers from departments aligned along more traditional disciplinary boundaries. This suggests that the U-M units founded on the idea of integrating a variety of academic disciplines under one departmental roof were inherently more open to the idea of collaborating across disciplinary boundaries.

The combination of these two points suggests that interdisciplinary collaboration is most likely to occur when departments are structured to encourage collaboration across disciplinary boundaries, by bringing multiple disciplines under a single roof. The creation of interdisciplinary institutes and schools within a larger institution is not a new phenomenon. One common approach is to focus these interdisciplinary institutes and schools by addressing a larger social

issue using a variety of approaches. Within U-M, examples of these schools include the School of Information (SI) and the School of Natural Resources and Environment (SNRE). These departments, and others like them, are usually built around the idea of providing researchers with a social environment that supports interdisciplinary collaboration, as well as easing the burden of finding collaborators.

SNRE distributed 39 tokens, 21 of which were funded. SNRE had the highest portion of three-unit projects of any unit that participated in MCubed. SNRE researchers created seven projects that eventually received funding, with SNRE collaborators on only two of those projects. Collaborators from nine units contributed to SNRE projects. SNRE researchers contributed tokens to projects from six different units, not including SNRE, as shown in the figure below. SNRE collaborators came from a total of ten different units, including Engineering, Law, and ISR.
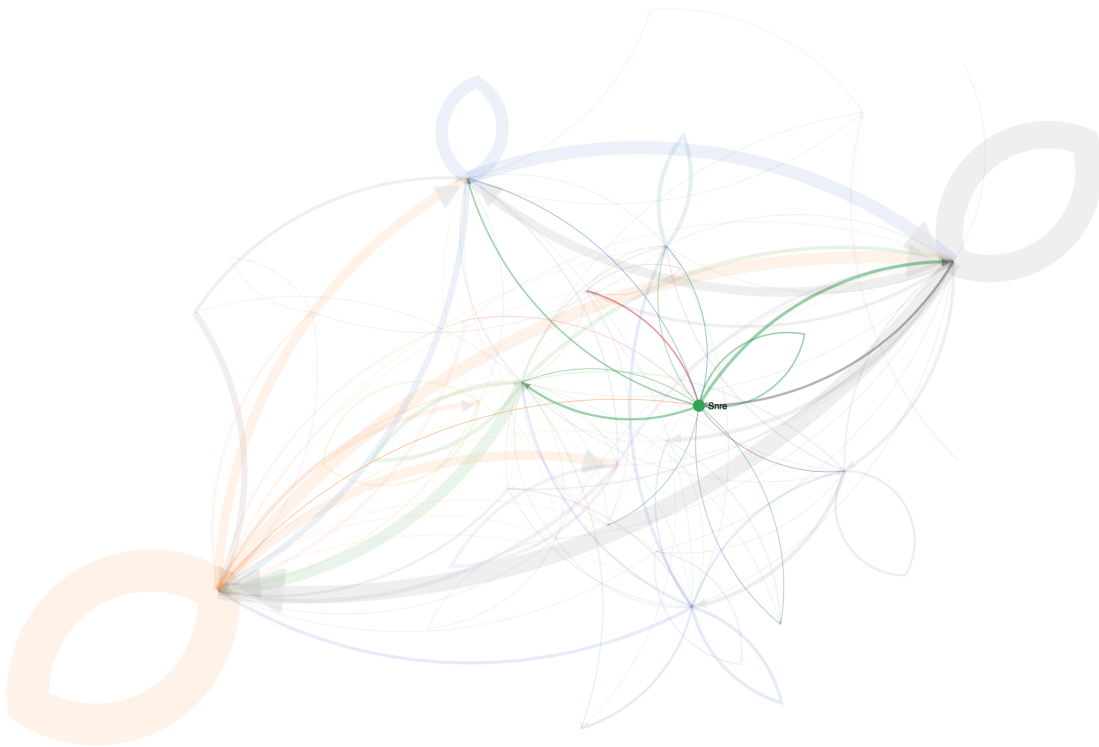
Figure 0-1: Network diagram of the results MCubed funding overall, with School of Natural Resources and Environment (SNRE) highlighted

Similarly to SNRE, SI distributed 36 tokens, 22 of which were funded. In contrast to SNRE, all six projects created and funded by SI token holders were two-unit projects. Collaborators from three units contributed to SI projects: Engineering, Social Science, and Public Health. SI researchers contributed tokens to projects from seven different units, not including SI, as shown in the figure below. Those units included Engineering, Public Health, and Education. SI collaborators came from a total of seven different units. One SI faculty member collaborated on an SNRE project. The collaborators on that particular project were all part of an interdisciplinary cluster hire.
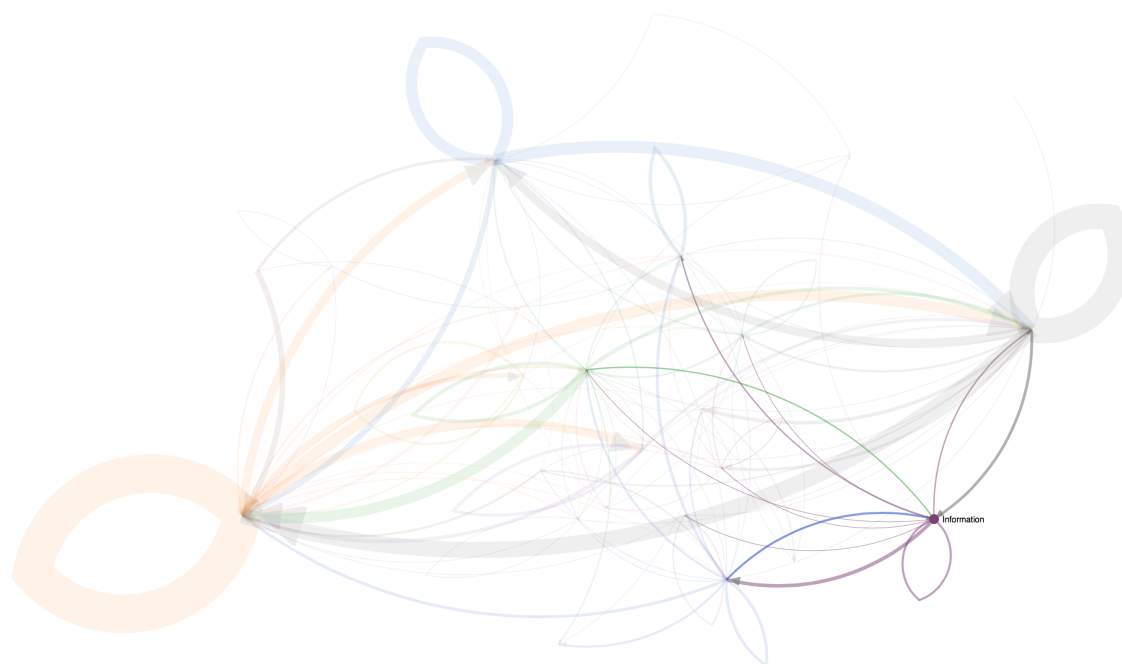
Figure 0-2: Network diagram of the results MCubed funding overall, with School of Information (SI) highlighted

In terms of the number of distributed tokens, funded tokens, and projects created, these two schools are very similar. SNRE and SI differ in two ways regarding their participation in MCubed. First, in the number of two- versus three-unit projects. Second, in the number of units that SNRE collaborated with. One reason for these differences may be the way in which these schools perform interdisciplinary research. SI originally focused on library and archival science. As technology progressed, SI expanded its mission to include related areas. For many, extending research on information search behavior to include human computer interaction may have seemed a natural extension. While SI is certainly interdisciplinary in its mission, it is specialized

159

in certain interdisciplinary areas such as Health Informatics. Additionally, SI in its current form was chartered about ten years after SNRE was chartered in its current form. SNRE has had an extra ten years or so to reach out to other schools and institutes across U-M.

Even after a school is well established, however, there are likely to be deep divides among faculty regarding the best way to approach a given problem. Additionally, those who come from disciplines whose approach is too different from that of the core faculty are often not successful in that department. For example, someone with a very qualitative design-based approach to research might have a difficult time getting established in a department that is highly focused on quantitative methods. While an interdisciplinary department may support a wider range of theories and methods than a department organized along traditional disciplinary boundaries, there will still be methods and theories that lie outside what that department views as valid research. Some degree of disciplinary overlap is beneficial and perhaps necessary.

These findings do not mean that those who argue for the benefits of interdisciplinary collaboration are wrong. If they were, the practice of establishing interdisciplinary departments within a larger institution would have ended a long time ago. But those benefits come with a strong caveat. A supportive institutional environment is critical, both in terms of finding collaborators in the first place, and producing desirable results once the collaboration is formed. The institutional environment must provide more concrete assistance than a one-time statement of support, no matter how strong that single statement is. To truly encourage interdisciplinary research, departments must recognize and acknowledge a wide range of creative output, rather than the usual traditional publication venues. Some disciplinary overlap helps, particularly in the beginning phases of a project.

5.4   Implications for Mcubed

As stated in Chapter 1, the original goal of MCubed can be summed up as encouraging "new groups to work together" on "bold research at the interfaces of academic fields" (MCubed, 2012; Moore, 2012). This goal can be restated as encouraging researchers who have not worked together previously, and encouraging researchers working on interdisciplinary projects. The question is then: what do the findings of this analysis mean for the relative success of MCubed?

First, I will tackle the goal of encouraging "new groups." Many projects formed within three days or less, indicating that collaboration arrangements were made prior to posting the

160

project online. This—combined with the number of projects where at least one pair of collaborators had a prior joint proposal—implies that the groups were not new. When you add the predominance of two-unit projects, it would seem that some degree of pre-existing familiarity and prior interaction were important factors in the formation of MCubed projects. This suggests that the focus on new collaborations was not beneficial. Perhaps, instead of simply focusing on new collaborations, the goal should be to increase the odds that a collaboration develops into a super tie that can ultimately result in increased publication and citation counts, which sustains career growth in the long run (Petersen, 2015). This would entail focusing on ways to build the trust, open communication, and mutual commitment to solving an overarching problem that are pre-requisites to the development of super ties (Hara, Soloman, Kim, & Sonnenwald, 2003; Petersen, 2015).

Second is the question of the interdisciplinary nature of the projects. If you add up the number of projects from the top three units (Medicine, Engineering, and LSA-Natural Sciences), the total (138) is more than half again as many as the total number of funded projects from the rest of the units combined (84). The project's unit is defined as the unit of the project creator. The majority of the projects in those three units were composed of two collaborators from the same unit, and one collaborator from a different unit (see Figure 5 in Chapter 2).
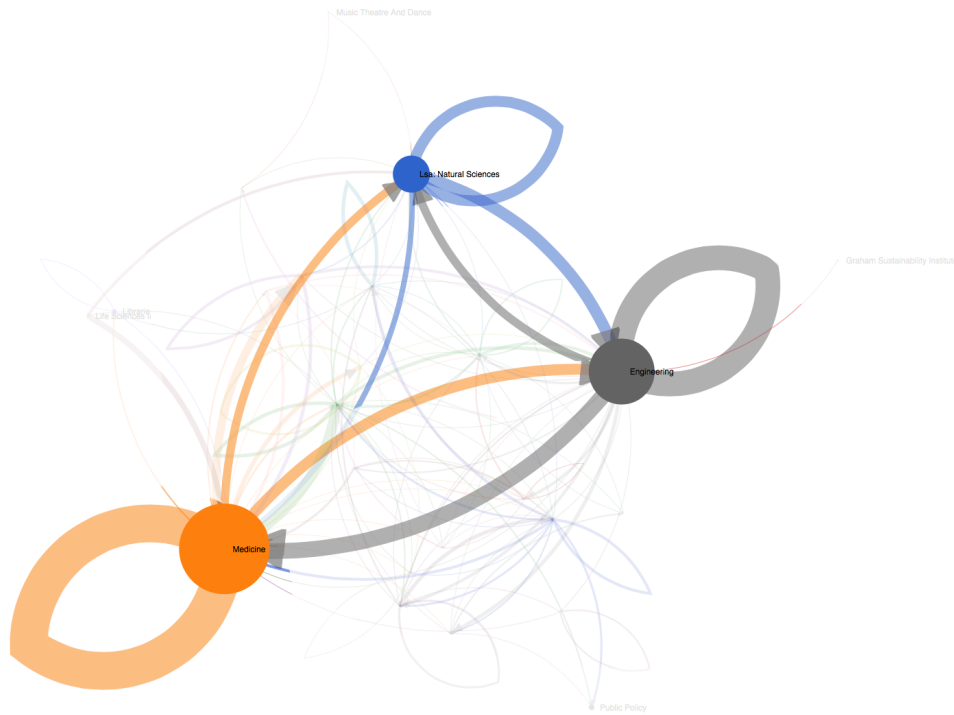
Figure 0-3: Network diagram of the results MCubed funding overall, with the top three units highlighted

Additionally, the top three units for project creation were also each other's most common collaborators (see Figure 5-3). For example, most Engineering token holders committed their tokens to Engineering, Medicine, or Natural Sciences projects, in that order. Most Natural Science token holders committed their tokens to Engineering, Natural Science, and Medicine projects. Medicine branched out a little more: Dentistry and Natural Sciences were tied for third in the number of token holders from Medicine committing tokens to projects. First and second place were Medicine and Engineering, respectively. Medicine dominated MCubed, both in terms of number of projects, and total tokens funded. Medicine would have been even more dominant had it not run out of fundable tokens in the middle of the second funding phase.

To some degree this is not surprising, because Engineering and Medicine distributed, and were willing to fund, the most tokens. On the other hand, it does not explain the dominance of LSA-Natural Sciences. The maximum number of funded tokens from Public Health, LSA-Social Sciences, and LSA-Humanities had numbers similar to those of LSA-Natural Science. Despite this, all three of these units had less than half the number of projects funded as did LSA-Natural Sciences. Something more than the number of tokens distributed, and maximum allowable

funded, was occurring, which may relate to the question of whether the institutional environment supported the type of interdisciplinary collaboration that was MCubed's goal.

One aspect of institutional support is the amount of funding available, which would certainly account for the lack of LSA-Humanities projects. Humanities research generally receives less national funding than other academic disciplines. Many researchers in LSA-Humanities were not able to cover the funds required for an individual contribution, and this limitation was frequently discussed at a variety of MCubed information sessions. One way to address this is to reduce the funding burden on individual researchers, especially those from disciplines that generally receive little funding. Some departments, such as MT&D, tried to take this burden from individual researchers. Unfortunately, these departments were also often short on funds, so the trade-off was to set a lower maximum number of fundable tokens. Even so, the amount of funding does not necessarily explain why Public Health did not play a larger role in MCubed.

The amount of funds provided by MCubed ($60,000 per project) had widely different implications for different fields. For some fields, $60,000 is barely enough to worry about. Research in fields like medicine or engineering often requires large, expensive pieces of equipment. In these fields, $60,000 may not be worth pursuing. But in the humanities, $60,000 seems like an exorbitant sum, especially when individual investigators must come up with $5,000 to $8,000 out of their own research funds. Hence, many researchers in low resource units were not able to participate in MCubed. The MCubed administrative team is attempting to address this issue in the second iteration of the MCubed initiative. On the low end, projects can receive $15,000, with a corresponding lower individual requirement. On the high end, projects can explicitly form larger blocks, thereby receiving multiples of $60,000. It remains to be seen whether those changes will make a difference.

This solution could still limit projects from fields that typically have fewer resources, but want to push boundaries. For example, the field of digital humanities is adding new, innovative tools to the traditional humanities toolbox. Some humanities researchers are digitizing decades worth of books and magazines so they can be analyzed using machine learning. Others are creating virtual models of historically significant sites. All of these projects require extra hardware, software, and skill sets that are often well outside the budget of a typical humanities

researcher. These researchers need the full $60,000 or more to accomplish their goals, but likely will not have the personal funds to cover the individual portion of the larger amount.

During information sessions, the MCubed administrative team suggested that collaborators from resource-rich units might be willing to offset some of the individual costs for collaborators from low resource units. Unfortunately, this strategy is highly dependent on finding the right collaborators, which could already be difficult for someone who does not have professional connections to faculty in a resource rich department. Another option could be to subsidize collaborators from low resource units in some way. These subsidies could take multiple forms. One option would be to set aside some portion of the funds from the Provost to support lower resource units. This would reduce the total number of projects that could be funded, but not all of the available funds were distributed to projects in the first iteration of MCubed. If that pattern was repeated, this may not be an issue. A second option would be to formalize the process of allowing collaborators from resource rich units to subsidize collaborators from resource poor units. The drawback to this solution is that researchers from resource poor units still need to find collaborators in resource rich units.

The peer-reviewed regression results from Chapter 4 indicate that more field similarity was linked to a higher likelihood of publishing in a peer-reviewed venue. This brings into question the goal of encouraging interdisciplinary work in the first place: projects that were less interdisciplinary were more likely to be published. The field-similarity result suggests that researchers can stretch their disciplinary boundaries to some degree, but larger distances between disciplines means that collaborators have a larger gulf to bridge. Bridging this gulf can happen, but it requires more time, effort, and institutional support. In terms of MCubed, the emphasis on widely disparate disciplines coming together on a project is not helpful.

5.5   Limitations and Future Work

There are multiple limitations, as well as many potential avenues for future studies, based on these findings. First, the combination of the low significance of the correlations discussed in Chapter 3, and the regression results for lightly-reviewed and non-reviewed/informal output in Chapter 4, indicate that some adjustment of the Scholarly Arc is necessary. Second, while this analysis described the social processes that surrounded the MCubed collaborations, I only touched on the social processes within a project. Third, this analysis looked at the funded

MCubed projects at a single point in time, but a longer view that looks at multiple points in time is necessary to truly understand the effect of MCubed on interdisciplinary collaboration at U-M.

5.5.1 Limitations in Chapter 2

The data sources described in Chapter 2 are inherently limited, especially the MCubed website log files. This data presents a small picture focused on the timeline of events on the MCubed website. No record exists of events that may have taken place outside the confines of the MCubed website. Hence, inferences about the reasons or actions that caused those website events must be confirmed using another method.

For example, Figure 5 and the first project illustrated suggest that collaborations that formed quickly did so because the researchers previously knew each other. When the pilot MCubed project was active, multiple surveys of the MCubed researchers were fielded by the MCubed Evaluation. The final report from the MCubed Evaluation goes into some detail about whether and how the researchers in those quick-to-form collaborations knew each other previously, but the next step is to perform a deeper analysis of this survey data to understand how that affected project output. Another question that can be at least partially answered by the surveys is why the researchers decided to collaborate, and what factored into those decisions. Additionally, the next step is to continue observing the projects to determine how successful the researchers involved in those projects were in generating results.

5.5.2 Limitations in Chapter 3

The CVs collected for this analysis were from researchers who were successful in getting pilot funding through MCubed, a university-sponsored project to increase interdisciplinary collaboration. Participation in this project varied both individually and by department. These CVs were also collected from faculty at a single university.

Each department set its own rules regarding which faculty members were eligible to participate in the program. These rules varied widely from one unit to another. Some departments limited participation to tenure-track faculty, while others allowed clinical and research faculty to participate. Rank was also a factor in some departments' determination of which faculty were eligible for the program. Also, the variance in the size of the departments was reflected in the CVs collected.

Eligible individuals demonstrated a wide range of activity when pursuing available funds. Some eligible researchers chose not to participate in the program because most researchers were required to contribute matching funds out of their own research accounts. This was a major barrier for departments with smaller budgets, such as humanities. Other researchers were actively trying to participate, but were unable to get a project funded through the program for a variety of reasons, which were discussed in Chapter 2.

Another limitation is that there is no standard format for CVs. The variety of ways in which the available CVs were truncated is an example of one way CVs lack a standard format. Invited talks were included in some, and not in others. Even when invited talks were included, some researchers only mentioned time and place, but did not mention what the talk was about. Since this analysis depended on analyzing complete CVs, the sample of CVs was limited in a way that could bias the results.

The main driver of full versus truncated CVs appeared to be the university unit or department. Departments that tended to have full CVs included the School of Information, Architecture & Urban Planning, and the School of Public Health. Departments that had truncated CVs included the Life Sciences Institute, the Medical School, and Dentistry. Therefore, the items in each of the Arc categories described above are likely tilted toward research outputs valued by the departments that encourage their faculty to make full CVs publicly available. In larger departments with a high percentage of truncated CVs (such as the Medical School) I was able to find enough complete CVs to ensure that research outputs were well represented in the Arc categories. Other units, such as Engineering, had a standardized CV format, which ensured that research outputs from the College of Engineering were included in the Arc. Smaller departments, such as the Life Sciences Institute and the Office of the Vice President of Research (OVPR), were more problematic. In those units, I was not able to find any complete CVs. Many of the faculty in these units have joint appointments in other university units, most notably Medicine. In most of these cases, the set of items included in the Arc is representative of the research output in these departments, resulting in minimal bias.

The most problematic university units were those focused on the arts. First, the sample of funded MCubed faculty in these units was small. For example, the number of faculty from Music, Theatre, & Dance was only two. Fortunately, these faculty members had complete CVs. The bigger bias was my own unfamiliarity with the types of creative output listed on those CVs.

In these cases, I looked up the publicly available tenure packages. The thought here was that if something was listed on a tenure package, it was more likely to be equivalent to the peer-reviewed items in fields I was more familiar with. This could result in a bias for faculty from these art-focused units.

The above limitation is compounded by the fact that this study was conducted for a single university. There are several implications. First, the guidelines for publicly posting complete CVs will likely differ across universities. Second, each university has its own set of disciplinary competences. Each scientific or creative discipline has its own set of unspoken guidelines, or norms, regarding what should go on an individual's CV, and whether that CV should be made public. Finally, while some researchers previously worked in industry, these CVs are targeted to an academic audience. Therefore, some of the research outputs that would be prioritized in other settings, such as government or industry, are not emphasized in this study.

Future work would involve addressing these limitations. In terms of departmental and individual differences, the next step would be to sample the CVs across all faculty at the university, rather than those researchers who were able to successfully participate in the university-sponsored project. To address the limitation of looking at a single university, CVs would need to be sampled at a variety of universities with similar levels of research activity. Finally, a later study should include research output from government and industrial organizations.

5.5.3 Adjusting the Scholarly Arc

By looking at the variety of outputs across a wide range of academic disciplines, my goal was to create a measure that examined early research outputs in addition to peer-reviewed outputs, obtaining a more temporally proximate view of the research projects. The Scholarly Arc is a good start. Nevertheless, more refinement is needed to make the temporally proximate categories more accurately reflect the research process.

The correlations between the four Scholarly Arc categories presented in Chapter 3 suggest reasons for why the models performed as they did. Non-reviewed output had lower correlations than all the other categories, and the correlation between non-reviewed and peer-reviewed output was particularly low. Moreover, the statistical significance of these correlations was low. Informal output was somewhat correlated with lightly-reviewed output, although this

correlation was statistically significant. While it is probably not surprising that informal output was not highly correlated with peer-reviewed output, the lack of statistical significance indicates that further refinement would be beneficial.

Collapsing the informal and non-reviewed categories into one category improved the statistical significance of the correlations, which was one reason I chose to use the collapsed categories in the output models for Chapter 4. The results of the peer-reviewed model confirmed the correlations found. Prior lightly-reviewed output increased the likelihood of having peer-reviewed output. Prior informal and/or non-reviewed output did not have a statistically significant effect on peer-reviewed publication, which is not surprising because the correlation between informal/non-reviewed output and peer-reviewed output was 0.290.

The definition of the various categories in the Scholarly Arc could be the difference between the relative number of statistically significant independent variables in the peer-reviewed versus the lightly-reviewed and non-reviewed/informal models. When defining the categories, it was easiest to set clear rules for the peer-reviewed category. Even in fields where peer-reviewed publications weren't common, there were other guidelines to give some idea of what would be equivalent, such as whether a given type of output was included in a tenure case. If that type of output was mentioned in a tenure case, it was judged to be equivalent to peer review. It was also easiest to find peer-reviewed output because almost all researchers include it on their CVs. Sometimes researchers will limit the items listed on a CV to the most influential or the most recent, but peer-reviewed output is always included on a researcher's CV.

The lightly-reviewed category was simpler than the non-reviewed and informal categories, but it was still more complex than peer-reviewed. Some people simply stated when something was lightly reviewed in their CV. This occurred most often in fields where conferences could be either peer-reviewed or lightly-reviewed: in general, fields related to Computer Science. Even in fields where conferences were never peer-reviewed, there was some ambiguity regarding what was lightly-reviewed and what was informal. Based on previous work, I based the definition on the relative size of the conference, designating national or international conferences as lightly-reviewed and departmental or university-based conferences as informal (Garvey, Lin, Nelson, & Tomita, 1972).

None of the correlations presented in Chapter 3 involving non-reviewed output were statistically significant, indicating that any refinement of the Scholarly Arc should start with non-

reviewed output. This is supported by the almost complete lack of statistically significant independent variables in the informal/non-reviewed models presented in Chapter 4. The reason for the lack of statistically significant correlations— and almost no statistically significant variables in the informal/non-reviewed models—could be because two general types of project output were categorized as non-reviewed output: (a) working papers and non-reviewed technical reports based on a research project, and (b) software or archives, which some researchers occasionally list on their CVs.

This indicates that research results could be included as a separate category in the Arc. Conceptually, this category would be positioned between informal and non-reviewed output. The informal category was conceived as venues where scholars could present their research during the early stages when ideas are being refined. For example, people usually discuss their ideas with the goal of getting feedback at departmental brown-bag lunch presentations and workshops, often with the goal of refining their data collection or analysis methods prior to submitting a paper to a more formal venue. Alternately, someone might give a brown-bag presentation with the goal of getting more test users for her software or prototype. The non-reviewed category was conceived as venues where research is in a more refined state. The research is usually complete, but the framing and small details are still in flux. The actual products of research, such as software or prototypes, would fall between these two.

The drawback is that only research geared toward application (rather than theory) would have output in a research product category. While this category would be useful when studying research in engineering and medicine, it would be almost useless when studying research in fields like economics or high-energy physics. It is not unusual for a computer science researcher to list software they have created on their CV or on a personal website, but it is quite unusual for economists to list all the contributions they have made to theory, because that information is contained in their publications. To list it separately would be pointless duplication.

The informal category performed better than the non-reviewed category in terms of statistically significant correlations to the other categories. The fact that neither peer-reviewed nor non-reviewed categories were statistically significant in the correlations presented in Chapter 3 suggests room for improvement. The fact that the informal/non-reviewed models in Chapter 4 performed so poorly supports this possibility. Again, refining the category definition might solve the problem. The informal category in the Scholarly Arc included things like keynote addresses.

169

These may more accurately belong in orthogonal category of the Scholarly Arc, because those are often based on a larger research agenda rather than on a specific research project. Workshops are also difficult to categorize into informal or lightly reviewed, because that differs by field. Workshops in many CS conferences are lightly reviewed, even if the discussion that takes place in the workshop is informal.

Before changing the definitions for the various Scholarly Arc categories, more fine-grained data should be collected. Semi-structured interviews with faculty members from various fields would help to refine the definitions. The goals for these interviews would fall into two categories. The first goal would be to clarify whether non-reviewed output should be separated into two separate categories. The second goal would be to ensure that less traditional outputs, such as performances or art exhibitions, are correctly categorized. Three general types of researchers should be interviewed to address these questions: (a) researchers in application-based fields where generating prototypes or software is common, (b) researchers from more theoretical fields, and (c) faculty members from fields that rarely have journal articles or conference papers, such as art or architecture.

The interviews for these various populations would all be based on the individual's own CV. Essentially, scholars would be asked to sort the items on their CVs into various piles. There are three possible ways the interviewer could approach this. (1) The interviewer could specify the general Arc categories, and ask that the scholar sorts the items based on the Arc categories. (2) Ask scholars to sort the items into separate projects. Scholars would be asked to perform a secondary sort by when a particular item was presented or by the type of venue where it was presented. (3) Let the scholars sort the items according to their own internal categories. This option would allow the interviewer to see the work in an entirely different way, and might result in insights that were not previously considered. Each option has its strengths and weaknesses, and a series of trial interviews would be necessary to determine the best course of action.

The next step would be to adjust the definitions of the Scholarly Arc categories based on the insights gained from the interviews, and validate those changes. The validation would be a multiple-step process. The first step would have another coder analyze a sample of CVs and test for inter-rater reliability. The second step would be to see if the categories accurately track the outputs of a single research project, as described in Chapter 3 under the heading "Step 3: Testing Arc Categories." The third step would be to re-categorize the outputs from the MCubed projects,

as described in Chapter 3 under the heading "Quantitative Verification of Scholarly Arc." To make the next steps comparable to the results presented here, I would need to limit the categorized output to output that was created before June 2015, when the data were collected for this analysis. The fourth step would be to re-run the Pearson correlations of the various outputs. This step would provide verification of the validity of the new category definitions in two ways. The first would be to check if the correlation increased between non-reviewed output and any of the other categories. The second type of validation in this step would be to see if the statistical significance of the Pearson correlations changes. The final step would be to re-run the regressions described in Chapter 4.

5.5.4 Limitations in Chapter 4

5.5.4.1 *Scholarly Arc as a dependent measure*

The Scholarly Arc categories offer an improvement over traditional measures of research output by allowing me to analyze outputs that are more temporally proximate to the actual research process. Nevertheless, aspects of the Scholarly Arc make it a rather coarse measure of research output: 1) no time component, 2) categories are aggregated, and 3) no analysis of output quality.

A major weaknesses of the dependent output measure used in this analysis was that it merely captured whether a project produced a certain type of output, rather than how long it took to produce that output. Essentially, this measure discarded potentially useful data. It is possible that using a different type of analysis, such as event history, would have produced a more nuanced analysis, particularly in the lightly-reviewed and informal/non-reviewed output categories. Perhaps if time had been included in these analyses, more independent variables would have become statistically significant.

Another weakness of the Scholarly Arc is that many different types of research output were aggregated into categories. Some of the aggregated items are roughly equivalent, such as peer-reviewed conference papers and journal articles. On the other hand, some outputs—such as technical reports and hardware prototypes—are less intuitively equivalent. Certainly, both technical reports and prototypes take time to produce, and neither is reviewed. As mentioned previously, more work is necessary to refine the Scholarly Arc, particularly the non-reviewed

category. Re-analyzing the data after those refinements are complete may reveal nuances that were obscured in this analysis.

When I developed the Scholarly Arc, I used funded proposals as a starting place for defining a project. Proposals were not included in the Scholarly Arc, and so this analysis did not address one of the stated goals of MCubed: to generate more funding proposals. Proposals could be considered an interim research output, because many federal agencies require researchers to provide preliminary data supporting the proposed research. I decided not to include proposals in the dependent measure, because I was using prior funded proposals as an independent variable. I felt that if I included both, somewhat of a chicken and egg problem would result in the analysis.

The Scholarly Arc only captures whether a research project generated a certain category of output. It does not, however, capture the relative quality of the output, unlike other research output measures. The journal H-index would capture this type of information—where an article was published, or an article's citation count. Because of this weakness, I was unable to test whether the outputs generated by MCubed funded projects were particularly innovative, which was one of the primary MCubed goals.

5.5.4.2 Relative publishing speed

Relative publishing speed within fields was included in an attempt to account for fields that published very quickly, such as computer science, and fields that published comparatively slowly, such as economics. This was constructed as a coarse measure, with units that had faculty who published in computer science venues categorized as fast, and other units categorized as slow. One could make the argument that a more fine-grained operationalization of the variable could have had a stronger effect on the results of various models.

Ideally, this measure would be an average of the amount of time between manuscript submission and final publication of an article for each of the three project collaborators. The problem is that not all journals make the time to publication readily available. For example, neither the *Journal of Pharmaceutical Sciences* nor the *Journal of Geophysical Research*, both associated with Wiley Online Library, make the time between submission and publication readily available. This lack of transparency, combined with the sheer number of journals where U-M researchers publish, makes operationalizing field publication speed a time-intensive task.

While the relative publication speed was never significant in any model, it did approach significance in some instances of the peer-reviewed and non-reviewed/informal models. Other control variables in the various models, particularly the peer-reviewed model, increased in significance as other variables were added, but this did not occur with the field publication speed variable. In fact, it tended to decrease in significance as other variables were added to the various models, indicating that the extra time to create a more fine-grained variable would not be worth the extra effort.

5.5.4.3 Prior interactions

Focusing on proposals privileges some areas over others. For example, researchers in medicine and engineering are much more likely to have joint NIH and NSF proposals than researchers from other areas, such as humanities. It may be that looking at prior joint proposals is capturing more than just previous experience working together. In this case, another measure may produce results more in line with previous research. One question asked in the MCubed evaluation surveys was how researchers had interacted prior to the MCubed project, including prior scholarly projects. I attempted to use this variable, but it was a survey response and decreased the number of cases available to the analysis, to the point where the results are questionable.

5.5.4.4 Institutional support

An option for operationalizing this variable was the ratio of the number of faculty in each unit who received a token, compared to the number of faculty in each unit who were eligible for a token. Unfortunately, this would have missed the units that gave tokens to almost all of their faculty but only agreed to fund a few of those tokens, such as Libraries and Music, Theatre, & Dance.

Perhaps a completely different operationalization of this variable not based on tokens, distributed or funded, would have produced different results. As mentioned earlier, survey responses regarding faculty members' perception of their unit's support for interdisciplinary collaboration would be useful. Almost all of the scales related to interdisciplinary collaboration included in the three MCubed Evaluation faculty surveys focused on individual researchers' support for interdisciplinary collaboration. The only scale that approached an individual's perceived unit support was one called "Sense of Community" (see Appendix). This scale focused

173

more on the sense of being a part of a community, rather than reflecting the perceived support for collaboration. There were also scales from the ADVANCE survey that reflected unit support for collaboration, but using these would have cut the number of cases available for analysis by more than half, which was not acceptable.

5.5.4.5 Field similarity

Some researchers were easier to disambiguate using this method than others. In most cases, differentiating between article sets was quite simple. For example, one set of keywords was related to medicine, and the other set was related to humanities literature. The more challenging authors to disambiguate were those with two different types of related keywords. For example, one article set could have keywords associated with cancer, and another keyword set on pregnancy. In these cases, I typically tried to match more than three keywords on my own search through an author's publications. While this method probably resulted in some articles wrongly rejected or included, it represents an improvement over the un-disambiguated names from the search results. Additionally, my intention was to get a general idea of an author's area of interest, rather than a perfectly accurate map of his or her publications.

5.5.5 Looking at funded MCubed projects into the future

Why is the peer-reviewed model described in Chapter 4 so different from the others? Almost all of the independent variables were statistically significant in the peer-review model, but only a few variables were statistically significant in the lightly-reviewed model and only one in the non-reviewed/informal model. In all of the models, the only significant class of independent variables was the set of coordination tools collaborators used.

These results represent a snapshot in time. It is possible that the significance or magnitude of any of the variables could change if the correlations or regressions were run at a different time. For example, the non-reviewed/informal models may have had more statistically significant variables had these models been run just prior to the first MCubed Symposium. Alternately, the peer-reviewed models would likely change if run after two to three years, with updated publication data.

One avenue of future work would be to run the regressions in Chapter 4 with data limited to what was gathered around the time of the first MCubed Symposium. This would involve limiting the data in two ways. First, all data gathered from CVs would be limited to research

174

outputs prior to November 2013. Second, data based on survey responses would be limited to the first and second MCubed Evaluation surveys. This type of analysis could reasonably be expected to result in significantly different results in all three models. At that point in time, most projects would have had primarily lightly-reviewed and non-reviewed/informal output rather than peer-reviewed output. Hence, some of the variables that were significant in the peer-reviewed models but not the others would become more significant. Relative field publishing speed could also have played a larger role in the peer-reviewed models. Communication and coordination may also have played a larger role.

The other direction of future work would be to run the models in Chapter 4 based on data one and two years into the future. Only the output dependent variables would change, and would need to be updated to include project outputs that came out after June 2015. It is likely that the peer-reviewed models in this case would look more like the lightly-reviewed and non-reviewed/informal models seen in Chapter 4. If this were the case, something other than logistic regression might be necessary to tease out the differences between projects. Event history analysis is more adept at capturing changes that occur over time, particularly the relationship between the independent variables and the length of time between two events (Box-Steffensmeier & Jones, 2004). In this case, it would be the length of time between a project being funded and the first point when a particular type of output category in the Scholarly Arc was achieved. Event history is preferable to simply using time as a dependent variable, because it accounts for the censoring that occurs when an event, such as publication in a peer-reviewed venue, has not occurred. This type of analysis would be best a year or two from now, when projects from fields that typically take longer to publish have peer-reviewed publications. Another advantage of this approach is that articles would have time to generate citations, which would allow testing of another MCubed goal: producing innovative and impactful research.

5.5.6 Future work: Digging deeper into team social processes

Even those who argue for the benefits of field diversity in research acknowledge that the social processes within a group greatly impact the output of that group (Page, 2007; Reiter-Palmon et al., 2011). It is not so much that interdisciplinary research does not work to create innovative solutions, but that the differences in approach must be resolved before moving

forward, and that takes more time (Castán Broto, Gislason, & Ehlers, 2009; Mauz et al., 2012; Pennington, 2011; Podestá, Natenzon, Hidalgo, & Toranzo, 2012).

The various surveys deployed by the MCubed Evaluation asked a number of questions that attempted to understand the amount and type of communication occurring in funded MCubed projects. These questions asked collaborators how often they communicated with their collaborators, how often they met in person with their collaborators, and research-based topics of discussion. The research-based discussion topics queried data collection, tools used, analysis methods, publication venues, and authorship order (see Appendix). All of these had low correlations with field diversity and the number of units involved in a project, which could be viewed as a proxy for field diversity. In fact, all of the correlations were between -0.1 and 0.2. Additionally, none of these had any effect when added to the various models.

The low correlations between field diversity and various measures of communication imply that these measures did not sufficiently capture the social processes that make interdisciplinary collaboration work. An interesting avenue for future work would be to observe the social processes that occurred in projects. Ideally, these processes would be observed in projects that were particularly high and particularly low on the field diversity measure, to allow for later analysis to compare and contrast the various projects. Based on these observations, a new set of survey questions could be generated and tested that would give a better picture of the social processes within an interdisciplinary collaboration.

5.6   Conclusion

A theme throughout all of the chapters was how the institutional context of a researcher's immediate department can limit the typical type of output a researcher generates (whether or not that researcher participates in an interdisciplinary research project) and the outcomes of that research project. One chapter was dedicated to enumerating the diverse set of potential outputs that can result from projects across the academic spectrum. Finally, I looked beyond the institutional environment to understand how team diversity and social processes affect the output of an interdisciplinary collaboration.

The MCubed initiative at the University of Michigan gave me the opportunity to take a deep look at many of the issues surrounding interdisciplinary collaboration. Interdisciplinary collaboration is fraught with challenges, the most important of which is simply finding others

with the necessary expertise who are willing to collaborate across disciplinary boundaries on a question of mutual interest. Once that connection is established, the challenges continue if collaborators do not find enough support in the institutional environment surrounding the project. The answer to the question of whether interdisciplinary collaboration can produce benefits depends to a large degree on whether interdisciplinary researchers can overcome these challenges.
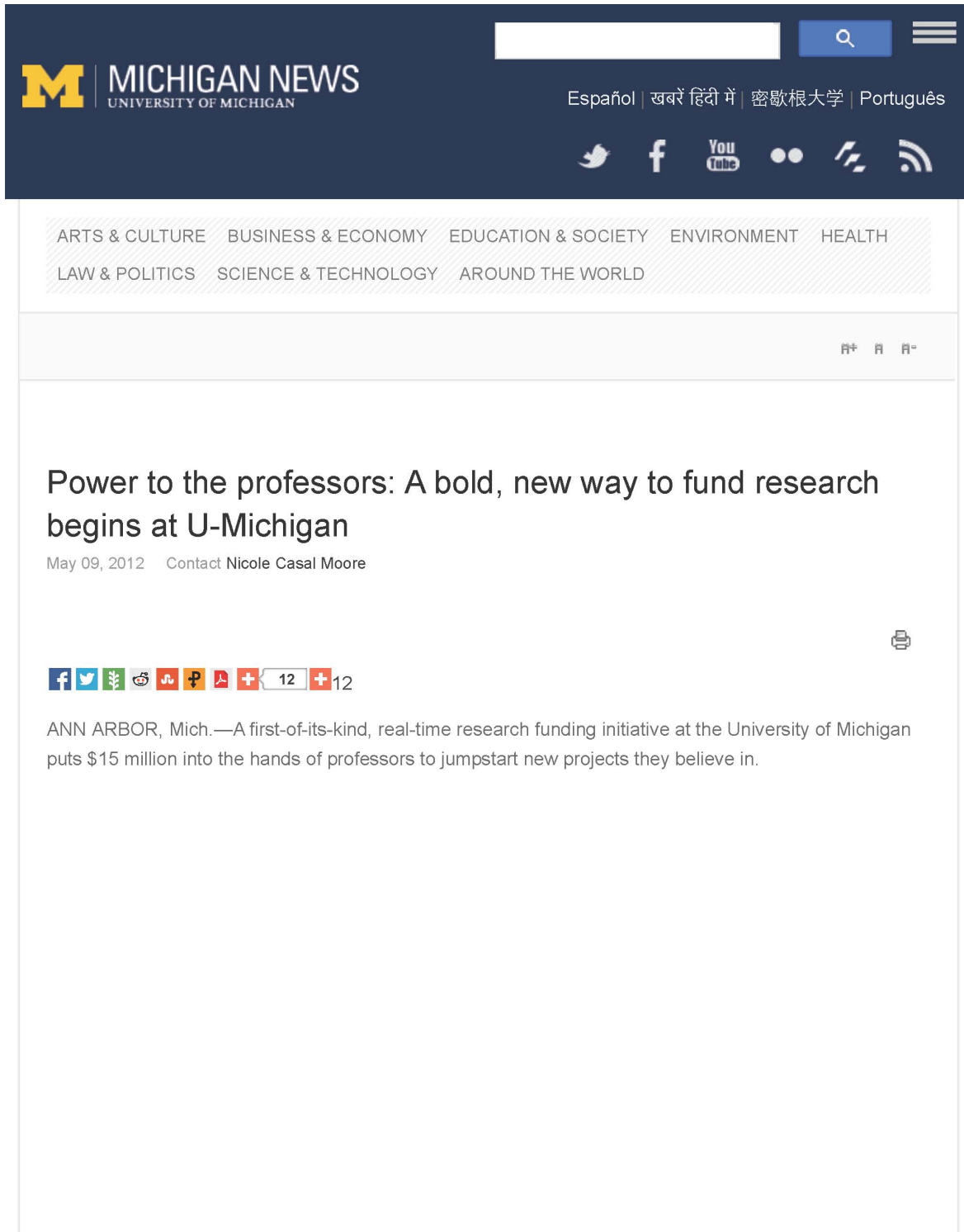
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Appendix

Source Materials

Mcubed Blog Entries And News About Mcubed

ARTS & CULTURE   BUSINESS & ECONOMY   EDUCATION & SOCIETY   ENVIRONMENT   HEALTH   LAW & POLITICS   SCIENCE & TECHNOLOGY   AROUND THE WORLD

Power to the professors: A bold, new way to fund research begins at U-Michigan

May 09, 2012   Contact Nicole Casal Moore

ANN ARBOR, Mich.—A first-of-its-kind, real-time research funding initiative at the University of Michigan puts $15 million into the hands of professors to jumpstart new projects they believe in.

Figure 0-1: Michigan News May 9 2012, page 1

To qualify, three researchers from different disciplines just need to come up with an idea and agree to work together.

A modern alternative to the traditional year-long government grant review process, the new MCubed program puts university professors in charge of divvying research dollars in a pure form of peer review.

MCubed is designed to encourage bold research at the interfaces of academic fields, where big breakthroughs tend to happen, according to the designers of the grassroots program.

MCubed, the University of Michigan's new real-time research funding initiative, was spearheaded by three engineering faculty members: Mark Burns, chair of chemical engineering; Thomas Zurbuchen, associate dean for entrepreneurial programs, and Alec Gallimore, associate dean for research and graduate education. Image credit: Laura Rudich, U-M College of Engineering

"The world has changed and yet higher education's funding model is the same. With the speed at which people communicate and share information today, we see an opportunity to do things in a very different way. This is a totally new model that could turn things upside down," said Mark Burns, professor and chair of chemical engineering. Burns spearheaded this effort along with professors Alec Gallimore and Thomas Zurbuchen, both associate deans in the College of Engineering.

Beginning this fall, departments, schools and colleges will allot a $20,000 token to each participating faculty member. Once three researchers decide to "cube," they register the project online on a first-come, first served basis. They immediately receive $60,000 to hire one graduate student, undergraduate student, or postdoctoral researcher, and work can begin.

Projects can grow, cube by cube. If 30 faculty members coalesce around one idea, for example, they could open a new large-scale research center with 10 funded positions overnight.

MCubed, a two-year pilot itself, aims to fund pilot studies that could eventually lead to larger traditional grants. It will give researchers new opportunities to follow their instincts, program designers say.

"In the traditional system, faculty are often forced to do research based on what will get funded, as opposed to what's the best idea or what is most important for society," Burns said. "Today those decisions are being made by external parties, and not by the best scientists in the world. MCubed will change that."

Figure 0-2: Michigan News May 9 2012, page 2

U-M is home to 95 top-ranked programs across the university.

"This program leverages the broad excellence of the University of Michigan. It unleashes some of the most brilliant minds in the world to pursue their most innovative ideas. You can think of it as smart crowdsourcing," said U-M Provost Phil Hanlon.

The provost's office has committed $5 million toward MCubed. Schools, colleges, and investigators must match that 2 to 1, making MCubed a $15 million program. A total of 250 projects will be funded in this pilot phase. Funded projects will present findings next year at an innovation showcase symposium.

"This is about making it big," said Thomas Zurbuchen, associate dean of entrepreneurial programs at the College of Engineering. "And sometimes that will mean failing big. It's about swinging for the fence, and we want to send the message that it's OK to miss."

A website where researchers can post and browse project ideas will launch this summer. As part of future phases of the program, the university is considering letting alumni or members of the public contribute directly to a project or submit new project ideas for researchers to consider.

"I can't wait to see the ideas that spring from this exciting initiative," said U-M President Mary Sue Coleman. "MCubed will give researchers new freedom and funding to act on their inspirations."

MCubed is the first program of U-M's Third Century Initiative, a $50 million, five-year plan to develop innovative, multidisciplinary teaching and scholarship.

The University of Michigan's $1.24 billion research budget is one of the largest in the nation. U-M is frequently first on the National Science Foundation's annual research spending rankings, most recently in 2010.

Related Links:

- MCubed: http://mcubed.umich.edu

RECENT FEATURES

Ethnicity impacts perceptions of mental health

Figure 0-3: Michigan News May 9 2012, page 3

17th August 2012 The cube is rolling

MCubed [http://mcubed.umich.edu/] , the new research seed-funding program here at the University of Michigan that was announced in May has actually been under development for years. It's exciting that we are finally getting close to the actual cubing process. We know that many of you have questions about the program. We have tried to answer the ones we can at this point in the Frequently Asked Questions section [http://mcubed.umich.edu/help] of the website, but some remain unanswered, and that's because we are still working out some of the details. This blog will keep you apprised as we put the finishing touches on this first-of-its-kind program.

What's happening now

The Executive Committee of MCubed is still talking with some of the colleges and schools around campus to secure their commitments to the program, which is a collaborative, rather than top-down, endeavor. Each unit will have slightly different rules and faculty eligibility, and we have to make sure that all of those align with the spirit of the program. Currently, we have positive responses indicating that every unit except one will participate. We're still working on that unit, and we hope to have 100% participation secured in the next month or so. That level of enthusiasm and excitement is just fantastic. When we started down this path, we never expected that it could be a University-wide endeavor. We envisioned perhaps five or six units being interested.

Website will allow comments

While we're still finalizing agreements with units, we are also busy building and loading information into the website. The website is key to this new program since it will facilitate the cubing process. When the site goes live, if you are eligible for a token, you'll be able to log in, find your profile (which we are creating right now), create project descriptions, find collaborators, and form cubes on the website. You'll also be able to comment on people's projects, and you'll be notified when people comment on yours. Finally, you will be able to see who else has a token and whether that person is available to potentially collaborate on your project.

Watch for your unit to officially sign up

To see if your unit has officially signed up, go to the contacts page of the website [http://mcubed.umich.edu/contact] . We post unit contact info once we have a signed memorandum of understanding from that unit. Coming soon to the website: details on the rules from each unit. Until that information is posted, you can reach out to the person listed as your unit contact for specific information about how this will unfold in your area.

We still have a few more months to go before cubing takes place. We expect that to begin sometime later in the Fall semester. We think the program will be worth the wait!

Posted 17th August 2012 by MCubed Team

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Figure 0-4: MCubed blog entry August 17 2012, page 1

184

8th October 2012 Unleashing Michigan innovation with MCubed

This is a guest post by Thomas Zurbuchen, MCubed co-founder and associate dean for entrepreneurial programs at the U-M College of Engineering. Read his blog [http://cfe.umich.edu/blog/] at the Center for Entrepreneurship.

This week, the University of Michigan [http://www.umich.edu/] is taking a risk – the university is gambling on the ingenuity of its researchers. Through a unique and new program called MCubed [http://mcubed.umich.edu/] , U-M is funding a researcher-in-training for a year to work on 250 or more projects that have some common characteristics: 1.) they are all interdisciplinary – including more than one academic unit in a project, 2.) they are new – no similar or identical work exists between the collaborators and 3.) they are high-risk/high-impact – submitting a proposal would be considered uncomfortably risky for funding agencies.

The key idea behind MCubed, initially conceived by Mark Burns [http://che.engin.umich.edu/people/burns.html] , who is a top researcher and innovator, is not in the recognition that we should do more innovative research and – especially here at U-M with its nearly 100 top-ten academic programs – focus on interdisciplinary research. It is in recognizing that the way you do this is by eliminating one of the biggest hurdles of such research – the peer review [http://www.labspaces.net/blog/366/The_NSF_review_panel_process] .

There is a lot of value to peer review, but it turns out that at the earliest stage of innovation peer review is to amazing creativity what water is to fire. Much research has been done about that early stage innovation and it turns out that at its earliest stage, creativity is stifled by team decisions. For example, when faced with tough innovation problems, individuals outdo teams who brainstorm [http://en.wikipedia.org/wiki/Brainstorming] when it comes to finding solutions to tough problems. Boundless creativity comes from the absence of consensus and the ability to break through accepted boundaries.

I recently met with a NASA [http://www.nasa.gov/] official and we commiserated about the demise [http://cfe.engin.umich.edu/blog/2009/01/the-parking-lots-at-night/] of NASA's innovation engine and our deep desire to rekindle that fire. We talked about the "ueber-bureaucracy" that often weigh down NASA missions and that drive innovators away like the devil is driven out by holy water. But, there is a challenge he mentioned to me: "You know, the most conservative part of our enterprise are the selections by peer-review." He is suggesting that scientists sitting on panels are often dominating and in fact driving the conservative orientation of new missions.

That struck a chord in me: I have been a member or chair of many selection panels and I know about the many good things peer review does once we are out of the earliest innovation stage. I actually do not think peer review is crooked or somehow bad for the field. It helps taxpayers save a lot of money by getting rid of truly bad ideas. Almost never have I seen a terrible idea get through the review. But, peer review is terrible at the earliest innovation stage – it likely kills the newest and most impactful proposals with the same vigor as it kills the bad ones. That's why one defining element of MCubed is that it allocates funding **without peer review**.

Figure 0-5: MCubed blog October 8 2012, page 1

But, there is more we learn about innovation: Teams will outdo individuals with respect to creativity when their members challenge each other through deep and engaged research built on trust. The University of Michigan can be prime location to build such new innovation teams, but that requires lots of interactions: in studies of innovation in research programs, it has been found that the professors that most interact with others are the ones that tend to write the most successful papers.

Here is the ticker: the number of lose interactions are more important for the impact of works than the number of co-authors. Interaction creates innovation. That's what MCubed seeks to do – one metric we try to change on campus is to increase the number of interactions each researcher makes with colleagues outside of their field. There is a lot of magic in this – check out an interview on Brad Bird's innovation lessons from Pixar [http://gigaom.com/2008/04/17/pixars-brad-bird-on-fostering-innovation/] to see analogies.

The University is taking a risk on it's researchers because it wants researchers to take more risks. Since we are in the middle of baseball playoff time: MCubed is about projects that seek to hit for the fence or even would like to see balls rolling down the street behind the ballpark. We want that so much that we prefer spectacular failures to hitting singles and doubles. This is a "big play" focused program!

Knowing the amazing quality of many of my colleagues here, the only thing I am worried about is that some people play it safe and spend the $60k/project to achieve a single if all we want is home runs and some spectacular failures!

Post author Thomas Zurbuchen is also a professor of atmospheric, oceanic and space sciences, and aerospace engineering.

Posted 8th October 2012 by MCubed Team

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Figure 0-6: MCubed blog October 8 2012, page 2

186

10th October 2012A cubing quandary: To wait in line or play the lottery?

With the tremendous enthusiasm for MCubed [http://mcubed.umich.edu/] right now, it is hard to see anything but positive signs. When we were in the initial phases of recruiting university units to the program, we thought it would be nice to have at least a handful of colleges and schools participate. But we now have essentially every unit on campus involved.

Such high interest means we have to be careful about the next phase: cubing.

To set the stage, we have funding from the Provost for $5 million that is matched 1-for-2. The rest comes from the university units and, in most cases, individual investigators. Thus, the program is $15 million or, in MCubed-speak, 750 tokens (250 cubes.) But if you add up all the commitments from the different units, they total more than 1,000 tokens. On top of that, most units are funding fewer tokens than they are distributing in an effort to encourage the broadest possible amount of collaboration and faculty involvement. The bottom line is that everyone who wants to cube might not be able to cube.

Thus, we have to make sure we use the best system for cubing, and that the system is consistent with the goals of the program. Most of all we have to make sure that it is fair and transparent.

Our first thought was a first-come, first-served approach. It seems straightforward and it might generate more excitement for the program. You know, like the thrill of trying to get tickets for a popular performer. Regardless of whether you got a ticket in the end, the process was always exciting, right? You could physically line up — either early with your tent and sleeping bag, or somewhere behind the die-hards. You could try calling, hoping to reach a Ticketmaster agent instead of a busy signal or to be stuck on hold for hours.

MCubed won't have a physical queue or telephone operator. Cubing will be an online process. And now that it's approaching, we realize it could involve thousands of researchers waiting by a computer, hand hovering over the return key getting set to repeatedly press it when the cubing function becomes active. Is that the best way to do this?

What would be better? We now think an essentially random draw of eligible cubing requests would cause less angst and uncertainty. That's how we'll be handling it for a 50-project pilot cubing phase at the end of the current interaction phase. During that time, the "request to cube" function will be available on the site for a week. During that week, we will make visible exactly how many tokens are left in each unit so that researchers can consider adjusting their cubes to maximize funding odds. And we will also guarantee that cubes are distributed around the campus as much as possible (i.e., so that each unit gets at least one cube).

After this 50-project pilot, we'll revisit the issue and, based on interest-level and logistics, we'll determine how to handle the remaining 200 cubes.

True, I wouldn't want to be told that my cube didn't receive funding after I had planned for it. But I would want to know I

Figure 0-7: MCubed blog October 10 2012, page 1

187

had a fair shot.

Our goals are to allow the most people to participate, to encourage dialogue across the university, and to make sure well-connected researchers have the same odds of forming a cube as new or less connected researchers. At this point, the random-drawing approach has the edge in that regard. In the end, there doesn't seem to be a perfect solution. But we are happy to hear your thoughts. Feel free to comment on this blog or send us a note by email at MCubedInfo@umich.edu. [mailto:MCubedInfo@umich.edu]

Posted 10th October 2012 by MCubed Team

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Figure 0-8: MCubed blog October 8 2012, page 2

13th November 2012 Impressive numbers and ideas

As of noon today, researchers have entered 193 projects into the MCubed website, growing it at approximately 10 projects per day. Faculty from across the campus are using the website to throw out amazing ideas and find partners to work on them. That, by itself, is a huge success! Well over 2,000 professors are making new connections and are taking advantage of one of the most unusual campuses for interdisciplinary breakthrough research.

Of those 193 projects, 70 teams (so-called "cubes") have officially requested funding. That means 210 faculty have committed their $20K tokens. And we just opened the website up for cubing yesterday early morning. Go blue!

Posted 13th November 2012 by MCubed Team

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Figure 0-9: MCubed blog November 13 2012, page 1

189

27th November 2012 Wednesday is cube day

The day we've all been waiting for is just about here. Tomorrow, we'll announce the first 50 teams to receive MCubed seed grants. As a way to underscore the novelty of the program, we've decided to name the funded projects in real time on Twitter as we go through our semi-random lottery process, beginning at 10 a.m. You can follow the action at @UmichResearch [https://twitter.com/UmichResearch] #mcubed [https://twitter.com/search?q=%23MCubed&src=hash] , and the projects will also appear on a new public page of the website. To see that page, go to mcubed.umich.edu [http://mcubed.umich.edu/] and click on the "Find a Project" tab without logging in. (Researchers will also receive an email notifying them whether their project was funded.)

If you're wondering why we call it "semi-random," that's because on first pass, we'll be taking care to ==ensure that every school, college or other participating university unit is represented in at least one project.== (We'll do that randomly, though.) For the remaining projects, we'll pick completely randomly, using a random number generator approved by the gaming industry.

The breadth of the collaborations in this program is astounding. We have physicists and musicians, architects and ophthalmologists, engineers and nurses, all proposing to work together on new projects. And from the descriptions, it's clear that faculty are attacking the problems they feel are important and interesting instead of merely responding to new calls for proposals. Researchers want to apply drone technology to children's health diagnostics. They want to look for dark matter with DNA. They want to see if nanoparticle soot from natural gas stovetops affects health. That's just a sampling of the many projects submitted so far.

We'll soon know which ones get a chance to move forward first. For those of you that don't receive funding in this initial round, don't worry. We'll have another round of cubing soon, so you'll have another shot. And if you haven't been on the website or committed your token yet, the website is still accepting new projects, and you can invite collaborators or ask to be invited as inspiration strikes. Congratulations to everyone who has already made MCubed a success by thinking across traditional disciplinary boundaries, posting compelling projects, and networking with new colleagues.

Posted 27th November 2012 by MCubed Team

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Figure 0-10: MCubed blog November 27 2012, page 1

190

MCubed Website
Semi-Random Cubing Description
December 12, 2012

      The semi-random selection process for picking the cubes from those requesting cubing for Phase 1 and Phase 2 was as described below. The general principles were that (a) we would first try to pick a cubes containing at least one token from every unit. In this description, a pre-cube is a project that is filled and has requested cube status (has requested funding).

1. **Random order list** – At the close of the cubing request period, the website will generate a list of all pre-cubes in a random order. This list will be used to select the valid cubes.

2. **All units represented by owner** – We will first try to pick a cube with an owner from each unit in the program. Starting with the first pre-cube and proceeding down the list, as a cube is selected, subsequent pre-cubes on the list with project owners from that same unit will be skipped. Also, one token will be subtracted from the available tokens in each of the investigators' corresponding units. When a unit runs out of tokens, all subsequent pre-cubes with investigators from that unit will be skipped.

3. **If not owners, use collaborators** – If all units are not represented in cubes after the above procedure, cubes with tokens from the non-represented units will be formed based on the other two tokens in the pre-cubes. The same process will be used as described above, skipping units that already have tokens in a cube or have run out of tokens. If all units are still not represented after this process is completed, this procedure and the above procedure (#2 and #3) may be modified to incorporate as many units as possible (e.g., switching the picking order of cubes containing tokens from non-represented units).

4. **Pick the rest randomly** – After the unit distribution phase has been completed, the rest of the cubes will be formed randomly. Again, the same procedure will be used as described above. Starting at the top of the list, cubes will be picked, skipping already picked cubes, and skipping pre-cubes containing tokens from units whose tokens are depleted. Pre-cubes with insufficient tokens (i.e., requiring two tokens from a unit that has only one token left) will be skipped. This cubing process will continue until all the pre-cubes have been processed or the total number of valid cubes for that cycle has been formed (e.g., 50 for the first cubing event), whichever comes first. Any pre-cubes that did not cube will be returned to the Filled Projects status.

Figure 0-11: MCubed Semi-Random Cubing Description

14th December 2012 What's the point in a cube?

Monday is the last day to get your MCubed [http://mcubed.umich.edu/] projects into the system and find collaborators for this second cubing phase, which ends at noon, Dec. 17. If you're still looking for collaborators, think about using the website to find new people who might be interested in working with you. So far, 96 teams have requested funding in this second round, but we're offering up to 150 grants in this cycle. There's a lot of room left!

If you aren't participating yet, you might be wondering why you should, or perhaps why the University is even doing this.

Well, let's start with some history. MCubed is a program that has been three years in the making. It began in a Medical School committee containing researchers from all over the university and industry who were trying to understand how academic research should be conducted in the next century. A seed from that group then grew at a faculty retreat in engineering and was funneled through IdeaWorks, a new initiative in engineering. From there, it spread across campus and is now one of the largest, cross-disciplinary programs in Michigan's history.

But that doesn't answer the questions. The "why" came from looking at how faculty typically choose new research directions. In many cases, they scan calls for applications from various agencies and attempt to shoehorn great ideas into proposals in such a way that the agency will accept them. Independently coming up with an idea and then writing a proposal without regard to funding agency restrictions and desires is almost unheard of. Thus, it feels as if those agencies, and not the Michigan faculty, are setting our research agendas.

Faculty and industry leaders designed MCubed as a way to change that and help Michigan researchers overcome some of the major barriers to innovation. It's hard to get funding to pursue the most groundbreaking projects. They're, by nature, high risks for funding agencies who often require preliminary results and even evidence that the grant requestors have experience working together before they'll bet on a bold proposal. We needed a program that would encourage new groups to work together and for researchers to follow their gut. One of MCubed's founders, Chemical

Figure 0-12: MCubed blog December 14 2012, page 1

192

Engineering Chair Mark Burns, knew firsthand how a small grant for a new idea could make all the difference. Less than $100,000 of seed money changed the course of his research in the early '90s.

Burns was in a meeting discussing DNA genotyping and sequencing technology when it struck him that the type of DNA analysis being discussed might work well on a chip, also known as a microfluidic device. He started talking with a geneticist in the room (David Burke, now a professor of human genetics at the U-M Medical School) and, after picking up an electrical engineer, the team agreed that they should work together to try and make the device. And it worked.

In a year's time, they were able to generate enough preliminary results to submit a successful NIH R01 proposal for over a million dollars. The resulting research program led to inexpensive tests for influenza and other applications, a landmark Science publication that has been cited more than 1,000 times, a T32 training program, and HandyLab, a company that Burns' students started and sold for $275 million to BD. All that would not have been possible without that initial funding for the interdisciplinary collaboration.

With MCubed, we hope to make this happen more often. True, not every discussion and ensuing project will have that kind of success. But we hope the availability of these funds will generate the discussions of the next generation of research without the artificial constraints of the agency directives. And even failures in this realm will be worthwhile — why and how a project fails often leads to insights on how to get it right the next time.

So what's your big idea? Why not start pursuing it now?

MCubed will fund up to 250 projects. The third funding phase will take place next semester, but this is the last opportunity for funding if you want to hire someone for Winter 2013. If you have questions as we approach the deadline, put them in the comments section below or email us at MCubedInfo@umich.edu [mailto:MCubedInfo@umich.edu] .

Posted 14th December 2012 by MCubed Team

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Figure 0-13: MCubed blog December 14 2012, page 2

193

17th January 2013 Innovation strikes again in second cubing phase

The second cubing phase, which closed on Monday, December 17th, once again stimulated a staggering array of projects that powerfully attest to the creativity and talent of U-M faculty. This phase resulted in funding for 117 cubes, which takes the total to 167 cubes funded so far in the pilot cycle of MCubed. (Read the previous post [http://mcubedmichigan.blogspot.com/2013/01/117-more-projects-funded-in-second.html] for an explanation of why all requested cubes could not be funded.)

Many projects address pressing social challenges. One cube plans to establish an interdisciplinary center to find solutions to the problems of financial management, regulation, and policy [http://mcubed.umich.edu/projects/center-finance-law-and-policy] laid bare by the recent financial crisis. Another project investigates responses to biophysical limits [http://mcubed.umich.edu/projects/urgent-transitions-responding-emerging-biophysical-limits] such as a declining energy supply, limited food security, and rising defensive expenditures. Still another examines the ways that creative expression benefits the health of caregivers and care recipients [http://mcubed.umich.edu/projects/retaining-identity-studying-creativitys-effects-caregivers-and-care-recipients] . Key themes across the 117 newly funded cubes are transportation, social media, cancer therapy, big data, and the human-machine interface.

The disciplinary range of the projects continues to be exciting, too. In both of the cubing phases thus far, the semi-random calculator begins by selecting a project from each participating campus unit (first by project owner, alternatively by collaborator) to promote broad representation of academic disciplines. Then it moves into purely random selection. We are very pleased that faculty from all 23 units with remaining tokens at the start of the semi-random selection process [http://mcubed.umich.edu/sites/default/files/files/SemiRandomSelectionJan2013.pdf] are included in this second group of funded projects.

Many cubes exceed the MCubed requirement of involving faculty from two different units, instead involving collaborators from three different units. Faculty from public policy, political science, and business are teaming up to investigate how a voter education program in the Philippines [http://mcubed.umich.edu/projects/combating-vote-selling-field-experiment-philippines] may reduce voters' willingness to sell their votes, a problematic phenomenon in many developing democracies. A scholar of German studies, a statistician, and a computer scientist are using distant reading and digital humanities techniques [http://mcubed.umich.edu/projects/digital-humanities-approaches-popular-periodicals-quantifying-reading-trends-time-series] to study mainstream German periodicals from 1850-1918. And through a state-of-the-art motion monitoring system, a social epidemiologist, a geriatrician, and an architectural designer are uncovering factors that impede independent mobility [http://mcubed.umich.edu/projects/understanding-role-built-environment-older-adult-mobility-using-mobile-technology] among older adults in urban areas.

Striking, too, are the notes of admiration for other cubes that faculty post within the internal MCubed website. In response to a project on social networking, student engagement, and learning outcomes [http://mcubed.umich.edu/projects/examining-curricular-extra-curricular-social-networks-and-their-relationship-student] , one professor of statistics admits that he can't "resist posting a comment on this really cool project" even though his own

Figure 0-14: MCubed blog January 17 2013, page 1

194

token is already committed elsewhere. He goes on to envision an ongoing university course on the future state of higher education. Other faculty commend cubes beyond their own for being important, vital, and substantive. And to the pleasure of the MCubed leadership team, some faculty begin to arrange meetings and collaborations that enlarge and build upon the cubed projects, taking innovation to an even higher level.

Looking for some inspiration on dreary winter day? From libraries and studios to labs and clinics, the innovative spirit is running high. Take a look at the latest cubes [http://mcubed.umich.edu/find-projects] ! And watch for an announcement soon about the next opportunity to seek a cube.

Posted 17th January 2013 by MCubed Team

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Figure 0-15: MCubed blog January 17 2013, page 2

195

Mcubed Evaluation Faculty Survey 1

Final version deployed on April 13, 2013

Q1 (Introduction)   Introduction   You recently received an email from the Provost describing a survey of research activity at the University of Michigan. This survey is part of a study being conducted by the Institute for Social Research at the University of Michigan with support from the Office of the Provost. Your participation in this study is voluntary. All responses will be anonymous and confidential and will be analyzed for statistical purposes only.

Although you may not benefit personally from participation in this study, others may from learning the results. Reports from the results of the study will be made to the University community, but only in an aggregated form.

If you have any questions about the study, you may contact the Behavioral Sciences IRB (http://www.irb.umich.edu/) or the principal investigator, Professor Michael Traugott, at mtrau@umich.edu.

On average, it should take about 15 minutes to complete this questionnaire.

Click on the arrow to continue to the next page.

Q5 (Trained) What are the fields in which you were trained? Please list up to three.

Q115 (Specialties) What are your field specialties? Please list up to three.

Q116 (WorkOtherUM) Since your terminal degree, have you worked anywhere other than the University of Michigan?

○ Yes (1)

○ No (2)

Answer If Since your terminal degree, have you worked anywhere othe... Yes Is Selected

Q117 Where did you work? Please check all that apply.

❑ Another academic institution (1) (WorkOtherUMAcademic)

❑ Private sector (2) (WorkOtherUMPrivate)

❑ Government (3) (WorkOtherUMGovt)

❑ Other, please specify (4) (WorkOtherUMOther) _____
(WorkOtherUMOtherTxt)

Q7 (HighestEd) What is the highest level of education that you have completed?

○ Did not complete Bachelor's degree (1)

○ Bachelor's degree (2)

○ Master's degree (3)

○ Professional degree (M.D., D.D.S, J.D., etc.) (4)

○ Doctoral degree (Ph.D.) (5)

Q8 (YearsExpr) Overall, how many years of experience do you have as a researcher (not counting years as a student)?

Q9 Here are some statements about dimensions of your working environment at the University of Michigan. Please indicate the extent to which you are dissatisfied or satisfied with each one. If you come to a statement that does not apply to your situation, please mark 'Not Applicable' (NA).

	Very Dissatisfied (1)	Somewhat Dissatisfied (2)	Neither Dissatisfied Nor Satisfied	Somewhat Satisfied (4)	Very Satisfied (5)	NA (9)

			(3)			
Opportunities to collaborate with other faculty? (1) (UMEnvCollab)						
Amount of social interaction with members of my unit/department? (2) (UMEnvSocial)						
Level of funding for my research or creative efforts? (3) (UMEnvFund)						
Sense of being valued as a mentor or advisor by my students? (4) (UMEnvMentor)						
Sense of being valued for my research, scholarship, or creativity by members of my unit/department? (5) (UMEnvValued)						
Level of stimulation in my day-to-day contacts with faculty colleagues? (6) (UMEnvStimulate)						

Table 0-1: Survey 1, U-M working environment

Q11 Are you a member of a well-established research team? By this we mean a collaboration that has existed for one year or more, or has submitted research proposals together, or has coauthored papers together, or has produced another form of research project together. Please check all that apply.

- ❑ Yes, I belong to a well-established research team. (1) (TeamYes)
- ❑ No, my research team cannot be considered a well-established one. (2) (TeamNotWellEst)
- ❑ I am not a member of a single research team. Depending on the project, I work with different teams. (3) (TeamNotOne)
- ❑ I usually work alone. (4) (TeamWorkAlone)

Answer If Are you a member of a well-established research team?&nbs... Yes, I belong to a well-established research team. Is Selected Or Are you a member of a well-established research team?&nbs... No, my research team cannot be considered a well-established one. Is Selected Or Are you a member of a well-established research team?&nbs... I am not a member of a single research team. Depending on the project, I work with different teams. Is Selected

Q12   Please give the number of collaborations or research teams you maintained during the last 3 years with…

Teams consisting of only University of Michigan researchers: (1) (NumUMCollab)

Teams consisting of only American researchers other than you: (2) (NumUSCollab)

Teams including at least one researcher from outside of the United States: (3) (NumIntlCollab)

Q14 We have a few questions about your your University of Michigan (U-M) campus workspace(s) that you use for research. Do you have more than one research workspace on the U-M campus? (CampusWorkspace)

❍ Yes (14)
❍ No (15)

Answer If Do you have more than one office on the UM campus for res... Yes Is Selected

Q118 In what building is your primary campus research workspace located? By primary campus research workspace, we mean the U-M campus location where you spend the most time doing your research. (WorkspaceBldg)

Q119 What proportion of your research do you accomplish in that workspace? Please enter a percentage. (PortionResearch)

Q20 Next, we would like your opinion about the physical qualities of your primary campus research workspace.   Which one of the following best describes your workspace? (PhysicalSpace)

❍ Private office with floor to ceiling walls (1)
❍ Shared office (with others) with floor to ceiling walls (2)
❍ Partitioned space with high panels (above eye level when standing) (3)
❍ Partitioned space with low panels (below eye level when standing) (4)
❍ Open space with others (5)
❍ Other, please describe: (6) _____ (PhysicalSpaceTxt)
❍ Not Applicable (7)

Q23 During your typical working day, how many times in connection with your research work do you leave the building where your primary campus research workspace is located? (LeaveBldg)

❍ Never (1)

❍ 1-2 times (2)

❍ 3-4 times (3)

❍ 5+ times (4)

Q24   How many hours in a typical week do you spend working on your research away from the building where your primary campus research workspace is located, including time spent working from home?   (WorkAway)

Q27   Now, on another topic, how many hours in a typical week do you spend in formal, planned meetings?   (WeeklyMeet)

Q28 Here are some statements about working with others. Please indicate the extent to which you disagree or agree with each one. If you come to a statement that does not apply to your situation, please mark 'Not Applicable' (NA).

	Strongly Disagree (1)	Somewhat Disagree (2)	Neither Disagree Nor Agree (3)	Somewhat Agree (4)	Strongly Agree (5)	NA (9)
There is a "sense of community" in my department. (1) (WorkOthersCommunity)						
Co-workers interrupt my work. (2) (WorkOthersInterrupt)						
The people I work with treat me well. (3) (WorkOthersTreatWell)						
The opportunity to talk informally with others is one of the reasons I enjoy						

my work. (5) (WorkOthersInformal)						
Communications seem good within my department. (7) (WorkOthersCommunicate)						

Table 0-2: Survey 1, working with others

Answer If Are you a member of a well-established research team?&nbs... Yes, I belong to a well-established research team. Is Selected Or Are you a member of a well-established research team?&nbs... No, my research team cannot be considered a well-established one. Is Selected Or Are you a member of a well-established research team?&nbs... I am not a member of a single research team. Depending on the project, I work with different teams. Is Selected

Q29   Next we would like to know about your general attitudes and satisfaction with your research collaboration(s). Please indicate the extent to which you disagree or agree with each statement. If you come to a statement that does not apply to your situation, please mark 'Not Applicable' (NA).

	Strongly Disagree (1)	Somewhat Disagree (2)	Neither Disagree Nor Agree (3)	Somewhat Agree (4)	Strongly Agree (5)	NA (9)
In general, collaboration has improved the quality of my research. (1) (CollabResQuality)						
Collaboration benefits my career. (2) (CollabResCareer)						
Other researchers in my field who do collaborative work are successful. (3) (CollabResSuccess)						
Collaboration is not common in my field. (4) (CollabResNotCommon)						

Collaboration is useful in solving problems that are of interest to me. (5) (CollabResUseful)						

Table 0-3: Survey 1, collaborative research

Q32 Here are some statements about interdisciplinary research. Please indicate whether you disagree or agree with each statement. If a statement does not apply to your situation, please mark 'Not Applicable' (NA).

	Strongly Disagree (1)	Somewhat Disagree (2)	Neither Disagree Nor Agree (3)	Somewhat Agree (4)	Strongly Agree (5)	NA (9)
It takes more time to produce a research article or product in an interdisciplinary research group (1) (InterdTime)						
I have changed the way I pursue a research idea because of my involvement in interdisciplinary research. (2) (InterdChange)						
Interdisciplinary research has improved how I conduct research. (3) (InterdImprove)						
I am optimistic that interdisciplinary research among collaborators leads to valuable research results that could not						

203

have occurred without that kind of collaboration. (4) (InterdValuable)					
Participating in an interdisciplinary team improves the research designs that are developed. (5) (InterdDesigns)					
Generally speaking, I believe that the benefits of interdisciplinary research outweigh the inconveniences and costs of such work. (6) (InterdBenefits)					
Interdisciplinary investigators as a group are open-minded about considering research perspectives from fields other than their own. (7) (InterdOpen)					
Publishing interdisciplinary research in my field can be difficult. (8) (InterdPublish)					
Interdisciplinary research works against people					

when it comes to tenure. (9) (InterdTenure)						

Table 0-4: Survey 1, interdisciplinary research

Q33   Thinking about your own experiences in the past, what barriers have you encountered when trying to establish research collaborations with investigators from other departments, institutions, or organizations?   Please check all that apply.

❑   Lack of time (1) (BarriersTime)

❑   Lack of funding (1) (BarriersFunds)

❑   Lack of support staff to assist with collaborative research efforts (1) (BarriersStaff)

❑   Limited awareness of opportunities to network with people outside my discipline (1) (BarriersAware)

❑   Lack of proximity to other researchers (1) (BarriersProximity)

❑   Lack of interest among potential partners (1) (BarriersInterest)

❑   Political or organizational pressures (1) (BarriersOrg)

❑   Have not encountered any major barriers (1) (BarriersNone)

❑   Other (please specify): (1) (BarriersOther) _____ (BarriersOtherTxt)

❑   Not applicable, never tried to collaborate (9) (BarriersNA)

Q34 The following items pertain to some of the thoughts and expectations you may have about your participation in research activities. Please indicate the extent to which you disagree or agree with each of the following statements. If you come to a statement that does not apply to your situation, please mark 'Not Applicable' (NA).

	Strongly Disagree (1)	Somewhat Disagree (2)	Neither Disagree Nor Agree (3)	Somewhat Agree (4)	Strongly Agree (5)	NA (9)
The research questions I am often interested in generally do not warrant collaboration from other disciplines. (1) (ResOrientNocollab)						

In my collaborations with others I integrate research methods from different disciplines. (2) (ResOrientMethods)						
In my own work, I typically incorporate theoretical perspectives from disciplinary orientations that are different from my own. (3) (ResOrientTheory)						
Although I was trained in a particular discipline, I devote much of my time to understanding other disciplines in order to inform my research. (4) (ResOrientUnderstand)						

Table 0-5: Survey 1, research orientation

Q35   Please assess the frequency with which you typically engage in each of the activities listed below using the following seven-category scale.

	Never (1)	Rarely (2)	Once a year (3)	Twice a year (4)	Quarterly (5)	Monthly (7)	Weekly or more frequently (8)
Read journals or publications outside of my primary field. (1) (CollabActRead)							
Attend meetings or conferences outside of my primary field. (2) (CollabActConference)							
Participate in working groups or committees with the intent to integrate ideas with other participants. (3)							

(CollabActCommittee)							
Obtain new insights into my own work through discussion with colleagues who come from different fields or disciplinary orientations. (4) (CollabActDiscuss)							
Establish links with colleagues from different fields or disciplinary orientations that have led to or may lead to future collaborative work. (5) (CollabActFuture)							
Collaborate with researchers from my own discipline on developmental projects. (6) (CollabActOwnDev)							
Collaborate with researchers from my own discipline in ways other than developmental projects. (7) (CollabActOwnOther)							
Collaborate with researchers outside of my discipline on developmental projects. (8) (CollabActOutDev)							
Collaborate with researchers outside of my discipline in ways other than developmental projects. (9) (CollabActOutOther)							

Table 0-6: Survey 1, collaborative activities

Answer If TokenLogin Is Equal to 0 Or TokenHolder Is Equal to 0

Q36 Have you heard or read about a new initiative at the University of Michigan called the MCubed project? (HeardMCubed)

❍ Yes (1)

❍ No (2)

❍ Not Sure (3)

If No Is Selected, Then Skip To End of Survey

Answer If   Have you heard or read about a new initiative at the Un... Yes Is Selected

Q37 What do you think the MCubed project is about?(MCubedAbout)

--- page break ---

Answer If Have you heard or read about a new initiative at the Univ... Yes Is Selected

Q40 MCubed has its own web site. Have you visited it? (VisitMCubed)

❍ Yes (1)

❍ No (2)

Q100 Were you eligible to receive an MCubed token from your home academic unit? (EligHome)

❍ Yes (1)

❍ No (2)

❍ I don't know (3)

Answer If Were you eligible to receive a token from your ... Yes Is Selected

Q41 Did you request an MCubed token from your home academic unit so that you could participate in the MCubed project? (RequestHome)

◯ Yes (1)
◯ No (2)

--- page break ---

Answer If Did you request a token so that you could participate in ... No Is Selected

Q42 Why didn't you request an MCubed token? (WhyNotRequestHome)

Q101 Were you eligible to receive an MCubed token from any other academic unit? (EligOther)

◯ Yes (1)
◯ No (2)
◯ I don't know (3)

Answer If Were you eligible to receive a token from any other acade... Yes Is Selected

Q102 Did you request an MCubed token from any other academic unit? (RequestOther)

◯ Yes (1)
◯ No (2)

Answer If Did you request a token from any other academic unit? Yes Is Selected

Q73 Which units were they? (RequestUnits)

Answer If Did you request a token from any other academic unit? No Is Selected

Q103 Why didn't you request an MCubed token from any other academic unit? (WhyNotRequestOther)

Answer If TokenHolder Is Equal to 1 And TokenLogin Is Not Equal to 0

Q43 The following section explores your experience with the MCubed program. Because we know your time is important, we have tailored this section based on your individual use of the MCubed website. (BeginMCubed)

Answer If NumberCollaborators Is Not Empty And NumberCollaborators Is Greater Than 0

Q44 On the MCubed website, ${e://Field/Collaborator1} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator1} prior to agreeing to collaborate with him/her? (KnowCollab1)

❍ Yes (1)
❍ No (2)

Answer If NumberCollaborators Is Greater Than or Equal to 2

Q45 On the MCubed website, ${e://Field/Collaborator2} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator2} prior to agreeing to collaborate with him/her? (KnowCollab2)

❍ Yes (1)
❍ No (2)

Answer If NumberCollaborators Is Greater Than or Equal to 3

Q87 On the MCubed website, ${e://Field/Collaborator3} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator3} prior to agreeing to collaborate with him/her? (KnowCollab3)

❍ Yes (1)
❍ No (2)

Answer If NumberCollaborators Is Greater Than or Equal to 4

Q88 On the MCubed website, ${e://Field/Collaborator4} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator4} prior to agreeing to collaborate with him/her? (KnowCollab4)

❍ Yes (1)
❍ No (2)

Answer If NumberCollaborators Is Greater Than or Equal to 5

Q89 On the MCubed website, ${e://Field/Collaborator5} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator5} prior to agreeing to collaborate with him/her? (KnowCollab5)

❍ Yes (1)
❍ No (2)

Answer If NumberCollaborators Is Greater Than or Equal to 6

Q90 On the MCubed website, ${e://Field/Collaborator6} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator6} to agreeing to collaborate with him/her? (KnowCollab6)

❍ Yes (1)
❍ No (2)

Answer If [Ask if NumberCollaborators = 1 or 2][Repeat for all coll... Yes Is Selected

Q46 How long (in years) have you known ${e://Field/Collaborator1}? (YearsKnowCollab1)

Answer If [Ask if NumberCollaborators = 1 or 2][Repeat for all coll... Yes Is Selected

Q48 Please check all the ways you have interacted with ${e://Field/Collaborator1}. Choose all that apply.

❑ We have never interacted prior to the MCubed project. (1) (PrevCollab1Never)

❑ We have worked on a prior project together, but did not work directly together or publish together. (2) (PrevCollab1Project)

❑ We have previously submitted a proposal together. (3) (PrevCollab1Proposal)

❑ We have previously presented or published together. (4) (PrevCollab1Publish)

❑ We have interacted socially. (5) (PrevCollab1Social)

Answer If NumberCollaborators Is Greater Than or Equal to 1

Q50 What were the major reasons you choose to collaborate with ${e://Field/Collaborator1} on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1) (ChooseCollab1Skill)

❑ Collaborator has special data or equipment. (2) (ChooseCollab1Equip)

❑ Development and testing of new methods. (3) (ChooseCollab1Method)

❑ Social reasons (old friends, past collaboration, etc.) (4) (ChooseCollab1Social)

❑ Mentor/mentee relationship. (5) (ChooseCollab1Mentor)

❑ Other, please specify. (6) (ChooseCollab1Other) _____ (ChooseCollab1OtherTxt)

Answer If NumberCollaborators Is Greater Than or Equal to 1

Q112 Please indicate how similar ${e://Field/Collaborator1}'s research field is to yours. (FieldCollab1)

❍ Same field, same subfield. (1)

❍ Same field, different subfield. (2)

❍ Different field. (3)

Q47 How long (in years) have you known ${e://Field/Collaborator2}? (YearsKnowCollab2)

Q49 Please check all the ways you have interacted with ${e://Field/Collaborator2}. Choose all that apply.

❑ We have never interacted prior to the MCubed project. (1) (PrevCollab2Never)

❑ We have worked on a prior project together, but did not work directly together or publish together. (2) (PrevCollab2Project)

❑ We have previously submitted a proposal together. (3) (PrevCollab2Proposal)

❑ We have previously presented or published together. (4) (PrevCollab2Publish)

❑ We have interacted socially. (5) (PrevCollab2Social)

Q51 What were the major reasons you choose to collaborate with ${e://Field/Collaborator2} on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1) (ChooseCollab2Skill)

❑ Collaborator has special data or equipment. (2) (ChooseCollab2Equip)

❑ Development and testing of new methods. (3) (ChooseCollab2Methods)

❑ Social reasons (old friends, past collaboration, etc.) (4) (ChooseCollab2Social)

❑ Mentor/mentee relationship. (5) (ChooseCollab2Mentor)

❑ Other, please specify. (6) (ChooseCollab2Other) _____ (ChooseCollab2OtherTxt)

Answer If NumberCollaborators Is Greater Than or Equal to 2

Q63 Please indicate how similar ${e://Field/Collaborator2}'s research field is to yours. (FieldCollab2)

❍ Same field, same subfield. (1)

❍ Same field, different subfield. (2)

❍ Different field. (3)

Answer If Did you know ${e://Field/Collaborator3} prior to agreeing... Yes Is Selected

Q91 How long (in years) have you known ${e://Field/Collaborator3}? (YearsKnowCollab3)

Answer If Did you know ${e://Field/Collaborator3} prior to agreeing... Yes Is Selected

Q95 Please check all the ways you have interacted with ${e://Field/Collaborator3}. Choose all that apply.

❑ We have never interacted prior to the MCubed project. (1) (PrevCollab3Never)

❑ We have worked on a prior project together, but did not work directly together or publish together. (2) (PrevCollab3Project)

❑ We have previously submitted a proposal together. (3) (PrevCollab3Proposal)

❑ We have previously presented or published together. (4) (PrevCollab3Publish)

❑ We have interacted socially. (5) (PrevCollab3Social)

Answer If NumberCollaborators Is Greater Than or Equal to 3

Q99 What were the major reasons you choose to collaborate with ${e://Field/Collaborator3} on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1) (PrevCollab3Skill)

❑ Collaborator has special data or equipment. (2) (PrevCollab3Equip)

❑ Development and testing of new methods. (3) (PrevCollab3Methods)

❑ Social reasons (old friends, past collaboration, etc.) (4) (PrevCollab3Social)

❑ Mentor/mentee relationship. (5) (PrevCollab3Mentor)

❑ Other, please specify. (6) (PrevCollab3Other) _____
   (PrevCollab3OtherTxt)

Answer If NumberCollaborators Is Greater Than or Equal to 3

Q108 Please indicate how similar ${e://Field/Collaborator3}'s research field is to yours. (FieldCollab3)

❍ Same field, same subfield. (1)

❍ Same field, different subfield. (2)

❍ Different field. (3)

Answer If Did you know ${e://Field/Collaborator4} prior to agreeing... Yes Is Selected

Q92 How long (in years) have you known ${e://Field/Collaborator4}? (YearsKnowCollab4)

Q96 Please check all the ways you have interacted with ${e://Field/Collaborator4}. Choose all that apply.

❑ We have never interacted prior to the MCubed project. (1) (PrevCollab4Never)

❑ We have worked on a prior project together, but did not work directly together or publish together. (2) (PrevCollab4Project)

❑ We have previously submitted a proposal together. (3) (PrevCollab4Proposal)

❑ We have previously presented or published together. (4) (PrevCollab4Publish)

❑ We have interacted socially. (5) (PrevCollab4Social)

Q100 What were the major reasons you choose to collaborate with ${e://Field/Collaborator4} on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1) (ChooseCollab4Skill)

❑ Collaborator has special data or equipment. (2) (ChooseCollab4Equip)

❑ Development and testing of new methods. (3) (ChooseCollab4Methods)

❑ Social reasons (old friends, past collaboration, etc.) (4) (ChooseCollab4Social)

❑ Mentor/mentee relationship. (5) (ChooseCollab4Mentor)

❑ Other, please specify. (6) (ChooseCollab4Other) _____ (ChooseCollab4OtherTxt)

Q109 Please indicate how similar ${e://Field/Collaborator4}'s research field is to yours. (FieldCollab4)

○ Same field, same subfield. (1)

○ Same field, different subfield. (2)

○ Different field. (3)

Answer If Did you know ${e://Field/Collaborator5} prior to agreeing... Yes Is Selected

Q93 How long (in years) have you known ${e://Field/Collaborator5}?
(YearsKnowCollab5)

Answer If Did you know ${e://Field/Collaborator5} prior to agreeing... Yes Is Selected

Q97 Please check all the ways you have interacted with ${e://Field/Collaborator5}.
Choose all that apply.
❑ We have never interacted prior to the MCubed project. (1) (PrevCollab5Never)
❑ We have worked on a prior project together, but did not work directly together or publish together. (2) (PrevCollab5Project)
❑ We have previously submitted a proposal together. (3) (PrevCollab5Proposal)
❑ We have previously presented or published together. (4) (PrevCollab5Publish)
❑ We have interacted socially. (5) (PrevCollab5Social)

Answer If NumberCollaborators Is Greater Than or Equal to 5

Q101 What were the major reasons you choose to collaborate with
${e://Field/Collaborator5} on an MCubed project? Choose all that apply.
❑ Collaborator has special competence. (1) (ChooseCollab5Skill)
❑ Collaborator has special data or equipment. (2) (ChooseCollab5Equip)
❑ Development and testing of new methods. (3) (ChooseCollab5Methods)
❑ Social reasons (old friends, past collaboration, etc.) (4) (ChooseCollab5Social)
❑ Mentor/mentee relationship. (5) (ChooseCollab5Mentor)
❑ Other, please specify. (6) (ChooseCollab5Other) _____
   (ChooseCollab5OtherTxt)

Answer If NumberCollaborators Is Greater Than or Equal to 5

Q110 Please indicate how similar ${e://Field/Collaborator5}'s research field is to yours. (FieldCollab5)

❍ Same field, same subfield. (1)

❍ Same field, different subfield. (2)

❍ Different field. (3)

Answer If Did you know ${e://Field/Collaborator6} to agreeing to co... Yes Is Selected

Q94 How long (in years) have you known ${e://Field/Collaborator6}? (Not shown)

Answer If Did you know ${e://Field/Collaborator6} to agreeing to co... Yes Is Selected

Q98 Please check all the ways you have interacted with ${e://Field/Collaborator6}. Choose all that apply. (Not shown)

❑ We have never interacted prior to the MCubed project. (1)

❑ We have worked on a prior project together, but did not work directly together or publish together. (2)

❑ We have previously submitted a proposal together. (3)

❑ We have previously presented or published together. (4)

❑ We have interacted socially. (5)

Answer If NumberCollaborators Is Greater Than or Equal to 6

Q102 What were the major reasons you choose to collaborate with ${e://Field/Collaborator6}on an MCubed project? Choose all that apply. (Not shown)

❑ Collaborator has special competence. (1)

❑ Collaborator has special data or equipment. (2)

❑ Development and testing of new methods. (3)

❑ Social reasons (old friends, past collaboration, etc.) (4)

❑ Mentor/mentee relationship. (5)

❑ Other, please specify. (6) _____

Answer If NumberCollaborators Is Greater Than or Equal to 6

Q111 Please indicate how similar ${e://Field/Collaborator6}'s research field is to yours. (Not shown)

❍ Same field, same subfield. (1)

❍ Same field, different subfield. (2)

❍ Different field. (3)

Answer If TokenFunded Is Equal to yes

Q55 Have you started work on your MCubed project yet? (StartWork)

❍ Yes (1)

❍ No (2)

Answer If NumberCollaborators Is Greater Than 0

Q52 Now thinking about your MCubed project, since you agreed to work on the project together, have you had regular communication with your MCubed collaborators? (M3Communicate)

○ Yes (1)
○ No (2)

Answer If NumberCollaborators Is Greater Than 0

Q53 How often have you communicated with your MCubed collaborators? (M3CommFreq)

○ Never (1)
○ Once (2)
○ Monthly (3)
○ Every other week (4)
○ Two or three times a week (5)
○ Daily (6)
○ As needed (7)
○ Other, please specify (8) _____ (M3CommFreqTxt)
○ Weekly (9)

Answer If How often have you communicated with your MCubed collabor... Never Is Not Selected And NumberCollaborators Is Greater Than 0

Q54 How often have you had scheduled meetings with your MCubed collaborators? (M3Meet)
❍ Never (1)
❍ Monthly (2)
❍ Every other week (3)
❍ Weekly (4)
❍ Two or three times a week (5)
❍ Daily (6)
❍ As needed (7)
❍ Other, please specify (8) _____ (M3MeetTxt)

Answer If TokenFunded Is Equal to yes

Q104 Have you identified someone to hire to work on the MCubed project? (M3HireID)
❍ Yes (1)
❍ No (2)

Answer If Have you hied someone to work on the project? Yes Is Selected

Q56 Whom have you hired to work on the MCubed project? Check all that apply.
❑ Hired an undergraduate student(s) (1) (M3HireUG)
❑ Hired a graduate student(s) (2) (M3HireGrad)
❑ Hired a post-doc(s) (3) (M3HirePostdoc)
❑ Planning to hire an undergraduate student(s) (4) (M3HirePlanUG)
❑ Planning to hire a graduate student(s) (5) (M3HirePlanGrad)
❑ Planning to hire a post-doc(s) (6) (M3HirePlanPostdoc)
❑ Other (7) (M3HireOther) _____ (M3HireOtherTxt)

Answer If Have you hied someone to work on the project? No Is Selected

Q57 Why have you not hired someone to work on the MCubed project? (WhyNotHire)

Answer If Who have you hired to work on the project? Check all that... Hired an undergraduate student(s) Is Selected

Q58 Did you know the undergraduate student(s) before you received MCubed funding? (KnowUG)

❍ Yes (1)
❍ No (2)

Answer If Did you know the undergraduate student(s) before you rece... Yes Is Selected

Q107 How did you know them? (HowKnowUG)

Answer If Who have you hired to work on the project? Check all that... Hired a graduate student(s) Is Selected

Q105 Did you know the graduate student(s) before you received MCubed funding? (KnowGrad)

❍ Yes (1)
❍ No (2)

Answer If Did you know the graduate student(s) before you received ... Yes Is Selected

Q108 How did you know them? (HowKnowGrad)

Answer If Who have you hired to work on the project? Check all that... Hired a post-doc(s) Is Selected

Q106 Did you know the post-doc(s) before you received MCubed funding? (KnowPostdoc)

❍ Yes (1)
❍ No (2)

Answer If Did you know the post-doc(s) before you received MCubed f... Yes Is Selected

Q109 How did you know them? (HowKnowPostdoc)

Q65 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.

❑ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1) (ViewM3Seed)
❑ Funding for brand new projects. (2) (ViewM3New)
❑ An additional source of funding for a project you had already begun working on. (3) (ViewM3Add)
❑ Funding meant to support a project for its entirety. (4) (ViewM3Entire)
❑ Other, please specify. (5) (ViewM3Other) _____ (ViewM3OtherTxt)

Answer If TokenHolder Is Equal to 0 Or TokenLogin Is Equal to 0

Q66 Why didn't you participate in MCubed? (WhyNotParticM3)

❍ Never applied for a token (1)
❍ Applied for a token, didn't get it (2)
❍ Received a token, decided not to use it (3)
❍ Didn't apply to my type of research (4)

If Didn't apply to my type of ... Is Selected, Then Skip To What are the aspects of the MCubed pr...

Answer If [Ask if TokenHolder = 2 or TokenLogin = 2]Why didn't you ... Never applied for a token Is Selected

Q67 Why did you decide not to apply for an MCubed token? Please check all that apply.

❑ Not interested in collaboration (1) (WhyNotApplyNoInterest)

❑ Too busy (2) (WhyNotApplyBusy)

❑ Not able to provide faculty-supplied funding (3) (WhyNotApplyFunds)

❑ Felt MCubed wasn't meant for me (4) (WhyNotApplyNotForMe)

❑ Other, please specify (5) (WhyNotApplyOther) _____
    (WhyNotApplyOtherTxt)

Answer If TokenHolder Is Equal to 1

Q68 Why did you decide not to use your MCubed token? Check all that apply.

❑ Unable to locate collaborators (1) (WhyNotUseCollab)

❑ Decided I was unable to provide the faculty-supplied funding (2) (WhyNotUseFunds)

❑ Decided I didn't have enough time (3) (WhyNotUseTime)

❑ Gave my token to someone else (4) (WhyNotUseGaveAway)

❑ Other, please specify (5) (WhyNotUseOther) _____
    (WhyNotUseOtherTxt)

Answer If TokenFunded Is Equal to yes

Q69 In your MCubed project, how often have you and your collaborators discussed the following aspects of your project? If you come to a statement that does not apply to your situation, please mark 'Not Applicable' (NA).

	Never Discussed (1)	Discussed Once or Twice (2)	Just Beginning to Discuss (3)	In the Middle of Discussion (4)	Discussed and Agreed to (5)	NA (6)
Methods to use when						

generating and processing data? (1) (CollabDiscussMethods)						
Data/material handling procedures both during and after data collection and analysis? (2) (CollabDiscussData)						
Publication venues? (3) (CollabDiscussPublication)						
Tools (e.g. software, equipment, etc.) to use during the course of your project (e.g. generating and processing data)? (4) (CollabDiscussTools)						
Authorship order? (5) (CollabDiscussAuthor)						

Table 0-7: Survey 1, collaborator discussions

Answer If TokenHolder Is Equal to 1

Q74 How would you describe your experience in applying for an MCubed token? (ExperApplyM3)

Answer If TokenHolder Is Equal to 1

Q110 Did someone else register your token on the MCubed website or did you do it yourself? (WhoRegToken)

○ Someone else (1)

○ Myself (2)

○ Don't know (3)

Answer If Did someone else register your token on the MCubed websit... Myself Is Selected

Q75 How difficult was it to register your token on the MCubed web site? (HardRegToken)

○ Not difficult at all (1)

○ Somewhat difficult, but I figured it out (2)

○ Difficult and I needed assistance (3)

○ Very difficult, never could get it registered (4)

Answer If NumberCollaborators Is Greater Than or Equal to 1

Q76 How many days did it take to find collaborators on the MCubed website? (DaysFindCollab)

Answer If NumberCollaborators Is Greater Than or Equal to 2

Q77 Did you receive funding for your project from the MCubed project? (ReceiveFunds)

○ Yes (1)

○ No (2)

○ Don't know yet (3)

Answer If NumberCollaborators Is Greater Than or Equal to 2 And Did you receive funding for your project from the MCubed ... No Is Selected

227

Q78 Why didn't you receive MCubed funding? (WhyNoFunds)

○ My unit ran out of tokens (1)

○ My collaborator's unit ran out of tokens (2)

○ My project was not selected in the first round of funding, and my unit ran out of tokens in the second round (3)

○ My project was not selected in the first round of funding, and my collaborators unit ran out of tokens in the second round (4)

○ Other, please specify (5) _____ (WhyNoFundsTxt)

Answer If TokenHolder Is Equal to 1

Q79 Overall, how would you describe your experience with the MCubed project to date? (ExperM3)

○ Very satisfied (1)

○ Somewhat satisfied (2)

○ Neither satisfied nor dissatisfied (3)

○ Somewhat dissatisfied (4)

○ Very dissatisfied (5)

Answer If TokenHolder Is Equal to 1

Q80 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with? (SatisfiedM3)

Answer If TokenHolder Is Equal to 1

Q81 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with? (DissatisfiedM3)

Q112 To better understand the effect of the MCubed program on research, a project staff member would like to speak with a subset of persons who have responded to this survey to ask

some more detailed questions. If you are selected in the subset, would you be willing to speak with the student? (DetailInterview)

❍ Yes (1)

❍ No (2)

Q113 If you have any additional comments or questions that have not already been covered in the survey, please enter them here.If you would like to contact the survey team directly, please email Professor Michael Traugott at mtrau@umich.edu. Once you are finished, please click the '>>' button to submit the survey. (AdditionalComments)

Mcubed Evaluation Faculty Survey 2

Final version deployed on October 25, 2013

Q1 You recently received an email describing a follow up survey of research activity at the University of Michigan. This survey is part of a study being conducted by the Institute for Social Research with support from the Office of the Provost. Your participation in this survey is voluntary. All responses will be anonymous and confidential and will be analyzed for statistical purposes only.

Although you may not benefit personally from participation in this study, others may from learning the results. Reports from the results of the study will be made to the University community, but only in an aggregated form. If you have any questions about the study, you may contact the Behavioral Sciences IRB (http://www.irb.umich.edu/) or the principal investigator, Professor Michael Traugott, at mtrau@umich.edu.

On average, it should take about 10 minutes to complete this questionnaire.

Please use the arrow buttons to navigate this survey.In this questionnaire, the term "project" refers to a proposed research activity, and the term "Cube" refers to a projects with three tokens committed to it, whether or not the project was funded. Click on the arrow to continue to the next page.

Q109 How did you use the MCubed website? (Select all that apply)

❑ Proposed my own project (1)

❑ Committed a token to someone else's project (2)

❑ Looked at other people's projects (3)

❑ Wanted to learn which individuals were participating in MCubed (4)

❑ Wanted to learn more about MCubed (5)

❑ Never logged in (6)

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q61 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.

❑ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1)

❑ Funding for brand new projects. (2)

❑ An additional source of funding for a project you had already begun working on. (3)

❑ Funding meant to support a project for its entirety. (4)

❑ Other, please specify. (5) _____

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q62 Overall, how would you describe your experience with the MCubed project to date?

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q63 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with?

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q64 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with?

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q89 If you have any additional comments or questions that have not already been covered in the survey, please enter them here.If you would like to contact the survey team directly, please email Professor Michael Traugott at mtrau@umich.edu. Once you are finished, please click the '>>' button to submit the survey.

If If you have any additional ... Is Displayed, Then Skip To End of Survey

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q123 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.

❑ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1)
❑ Funding for brand new projects. (2)
❑ An additional source of funding for a project you had already begun working on. (3)
❑ Funding meant to support a project for its entirety. (4)
❑ Other, please specify. (5) _____

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q124 Overall, how would you describe your experience with the MCubed project to date?

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q125 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with?

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q126 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with?

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q127 If you have any additional comments or questions that have not already been covered in the survey, please enter them here.If you would like to contact the survey team directly, please email Professor Michael Traugott at mtrau@umich.edu. Once you are finished, please click the '>>' button to submit the survey.

If If you have any additional ... Is Displayed, Then Skip To End of Survey

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q128 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.

❑ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1)

❑ Funding for brand new projects. (2)

❑ An additional source of funding for a project you had already begun working on. (3)

❑ Funding meant to support a project for its entirety. (4)

❑ Other, please specify. (5) _____

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q129 Overall, how would you describe your experience with the MCubed project to date?

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q130 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with?

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q131 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with?

Answer If How did you use the MCubed website? (Select all that apply) Never logged in Is Selected

Q132 If you have any additional comments or questions that have not already been covered in the survey, please enter them here.If you would like to contact the survey team directly, please email Professor Michael Traugott at mtrau@umich.edu. Once you are finished, please click the '>>' button to submit the survey.

If If you have any additional ... Is Displayed, Then Skip To End of Survey

Answer If How did you use the MCubed website? (Select all that apply) Committed a token to someone else's project Is Selected Or How did you use the MCubed website? (Select all that apply) Looked at other people's projects Is Selected

Q4 How many projects did you contact to obtain additional information?

Answer If How did you use the MCubed website? (Select all that apply) Committed a token to someone else's project Is Selected Or How did you use the MCubed website? (Select all that apply) Looked at other people's projects Is Selected

Q5 How many projects did you contact about collaborating?

Answer If How did you use the MCubed website? (Select all that apply) Proposed my own project Is Selected

Q7 How many expressions of interest did you receive for your project?

Answer If How did you use the MCubed website? (Select all that apply) Proposed my own project Is Selected

Q8 How many did you invite to participate on your project?

234

Answer If How did you use the MCubed website? (Select all that apply) Proposed my own project Is Selected

   Q9 How many of those you invited to participate agreed to collaborate on your project?

Answer If How did you use the MCubed website? (Select all that apply) Proposed my own project Is Selected

   Q10 Were you able to form a Cube by getting at least two collaborators?
○ Yes (1)
○ No (2)

Answer If Were you able to form a Cube by getting at least two coll... No Is Selected

   Q12 Why not?

Answer If How did you use the MCubed website? (Select all that apply) Committed a token to someone else's project Is Selected

   Q11 Were you able to join a Cube?
○ Yes (1)
○ No (2)

Answer If Were you able to join a Cube? No Is Selected

   Q13 Why not?

Answer If Why not? Text Response Is Displayed Or Why not? Text Response Is Displayed

Q88 After you were unable to form a Cube, did you commit your token to a different project that did get Cubed?

❍ Yes (1)

❍ No (2)

Answer If Did you commit your token to a someone else's project tha... No Is Selected

Q90 Why not?

If Why not? Is Displayed, Then Skip To End of Block

Answer If How did you use the MCubed website? (Select all that apply) Proposed my own project Is Selected Or How did you use the MCubed website? (Select all that apply) Committed a token to someone else's project Is Selected

Q15 Was your project funded?

❍ Yes (1)

❍ No (2)

Answer If Was your project funded? No Is Selected

Q16 Do you know why you didn't receive MCubed funding?

Answer If Do you know why you didn't receive MCubed funding? Text Response Is Displayed

Q70 Did you commit your token to a someone else's project that was Cubed and funded?

❍ Yes (1)

❍ No (2)

Answer If Did you commit your token to a someone else's project tha... No Is Selected

Q71 Why not?

Answer If Was your project funded? Yes Is Selected

Q17 When did the funding for your MCubed project become available for you to use?
[TABLE OF POSSIBLE DATES DELETED TO SAVE SPACE IN PRINT VERSION]

Q18 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.
- ❑ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1)
- ❑ Funding for brand new projects. (2)
- ❑ An additional source of funding for a project you had already begun working on. (3)
- ❑ Funding meant to support a project for its entirety. (4)
- ❑ Other, please specify. (5) _____

Q19 Overall, how would you describe your experience with the MCubed project to date?

Q20 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with?

Q21 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with?

Q90 If you have any additional comments or questions that have not already been covered in the survey, please enter them here.If you would like to contact the survey team

directly, please email Professor Michael Traugott at mtrau@umich.edu. Once you are finished, please click the '>>' button to submit the survey.

Q133 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.

❑ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1)

❑ Funding for brand new projects. (2)

❑ An additional source of funding for a project you had already begun working on. (3)

❑ Funding meant to support a project for its entirety. (4)

❑ Other, please specify. (5) _____

Q134 Overall, how would you describe your experience with the MCubed project to date?

Q135 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with?

Q136 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with?

Q137 If you have any additional comments or questions that have not already been covered in the survey, please enter them here.If you would like to contact the survey team directly, please email Professor Michael Traugott at mtrau@umich.edu. Once you are finished, please click the '>>' button to submit the survey.

Q138 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.

❑ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1)

❑ Funding for brand new projects. (2)

❑ An additional source of funding for a project you had already begun working on. (3)

❑ Funding meant to support a project for its entirety. (4)

❑ Other, please specify. (5) _____

Q139 Overall, how would you describe your experience with the MCubed project to date?

Q140 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with?

Q141 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with?

Q142 If you have any additional comments or questions that have not already been covered in the survey, please enter them here.If you would like to contact the survey team directly, please email Professor Michael Traugott at mtrau@umich.edu. Once you are finished, please click the '>>' button to submit the survey.

If If you have any additional ... Is Displayed, Then Skip To End of Survey

Answer If NumCollaborators Is Greater Than or Equal to 1

Q75 On the MCubed website, ${e://Field/Collaborator1} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator1} prior to agreeing to collaborate with him/her?

❍ Yes (1)

❍ No (2)

Answer If NumCollaborators Is Greater Than or Equal to 2

Q77 On the MCubed website, ${e://Field/Collaborator2} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator2} prior to agreeing to collaborate with him/her?

❍ Yes (1)

❍ No (2)

Answer If On the MCubed website, ${e://Field/Collaborator1} was ind... Yes Is Selected

Q79 How long (in years) have you known ${e://Field/Collaborator1}?

Answer If On the MCubed website, ${e://Field/Collaborator1} was ind... Yes Is Selected

Q28 How did you know ${e://Field/Collaborator1}? Check all that apply.

❑ Collaborated on a proposal (1)

❑ Collaborated on a research project (2)

❑ Collaborated on a performance, exhibition, or other creative output (3)

❑ Co-authored a conference paper, article, chapter, or book (4)

❑ Presented together (5)

❑ Co-taught a course (6)

❑ Departmental colleague (7)

❑ Interacted socially (8)

❑ Other, please specify (9) _____

Answer If NumCollaborators Is Greater Than or Equal to 1

Q83 What were the major reasons you choose to collaborate with ${e://Field/Collaborator1} on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1)
❑ Collaborator has special data or equipment. (2)
❑ Development and testing of new methods. (3)
❑ Social reasons (old friends, past collaboration, etc.) (4)
❑ Mentor/mentee relationship. (5)
❑ Other, please specify. (6) _____

Answer If NumCollaborators Is Greater Than or Equal to 1

Q85 Please indicate how similar ${e://Field/Collaborator1}'s research field is to yours.

○ Same field, same subfield. (1)
○ Same field, different subfield. (2)
○ Different field. (3)

Answer If On the MCubed website, ${e://Field/Collaborator2} was ind... Yes Is Selected

Q87 How long (in years) have you known ${e://Field/Collaborator2}?

Q95 How did you know ${e://Field/Collaborator2}? Check all that apply.

❑ Collaborated on a proposal (1)

❑ Collaborated on a research project (2)

❑ Collaborated on a performance, exhibition, or other creative output (3)

❑ Co-authored a conference paper, article, chapter, or book (4)

❑ Presented together (5)

❑ Co-taught a course (6)

❑ Departmental colleague (7)

❑ Interacted socially (8)

❑ Other, please specify (9) _____

Q91 What were the major reasons you choose to collaborate with ${e://Field/Collaborator2} on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1)

❑ Collaborator has special data or equipment. (2)

❑ Development and testing of new methods. (3)

❑ Social reasons (old friends, past collaboration, etc.) (4)

❑ Mentor/mentee relationship. (5)

❑ Other, please specify. (6) _____

Q93 Please indicate how similar ${e://Field/Collaborator2}'s research field is to yours.

○ Same field, same subfield. (1)

○ Same field, different subfield. (2)

○ Different field. (3)

Answer If Was your project funded? Yes Is Selected Or Did you commit your token to a someone else's project... Yes Is Selected

Q30 Since the project began, has the set of collaborators changed?

O Yes (1)

O No (2)

If No Is Selected, Then Skip To Was there anyone else who was invited...

Answer If TokenFunded Is Equal to 1

Q31 Did any collaborators drop out?

O Yes (1)

O No (2)

Answer If Did any collaborators drop out? Yes Is Selected

Q32 Why did they drop out?

Answer If TokenFunded Is Equal to 1

Q33 Did new any collaborators join the project?

O Yes (1)

O No (2)

Answer If Did any collaborators join the project? Yes Is Selected

Q34 How many new collaborators joined the project?

Answer If TokenFunded Is Equal to 1

Q35 Was there anyone else who was invited to participate, but didn't?
❍ Yes (1)
❍ No (2)

Answer If Was there anyone else who was invited to participate, but... Yes Is Selected

Q36 Why didn't they participate in the project?

Answer If How did you use the MCubed website? (Select all that apply) Committed a token to someone else's project Is Selected

Q37 How satisfied are you with your experience with MCubed to complete arrangements for your project?
❍ Very satisfied (1)
❍ Somewhat satisfied (2)
❍ Not at all satisfied (3)

Answer If How did you use the MCubed website? (Select all that apply) Committed a token to someone else's project Is Selected

Q99 Please describe any problems you encountered with MCubed to complete arrangements for your project.

Answer If How did you use the MCubed website? (Select all that apply) Committed a token to someone else's project Is Selected

Q39 How satisfied are you with your experience with your home administrative unit to complete arrangements for your project?
❍ Very satisfied (1)
❍ Somewhat satisfied (2)
❍ Not at all satsified (3)

Answer If How did you use the MCubed website? (Select all that apply) Committed a token to someone else's project Is Selected

Q100 Please describe any problems you encountered with your home administrative unit to complete arrangements for your project.

Answer If TokenFunded Is Equal to 1

Q22 Have you started work on your MCubed project yet?
❍ Yes (1)
❍ No (2)

Answer If TokenFunded Is Equal to 1

Q23 How often have you communicated with your MCubed collaborators?

❍ Never (1)
❍ Once (2)
❍ Monthly (3)
❍ Every other week (4)
❍ Weekly (5)
❍ Two or three times a week (6)
❍ Daily (7)
❍ As needed (8)
❍ Other, please specify (9) _____

Answer If TokenFunded Is Equal to 1

Q24 How often have you had scheduled meetings with your MCubed collaborators?

❍ Never (1)
❍ Once (2)
❍ Monthly (3)
❍ Every other week (4)
❍ Weekly (5)
❍ Two or three times a week (6)
❍ Daily (7)
❍ As needed (8)
❍ Other, please specify (9) _____

Q25 Which of the following coordination tools have you used? Check all that apply.

- ❑ Google Docs/Cloud applications (1)
- ❑ MBox/Dropbox/Cloud file storage (2)
- ❑ Other shared filed repository (3)
- ❑ Project intranet/wiki/website (4)
- ❑ Project database (5)
- ❑ Other (6) _____
- ❑ None of the above (7)

Q26 In your MCubed project, how often have you and your collaborators discussed the following aspects of your project? If you come to a statement that does not apply to your situation, please mark 'Not Applicable' (NA).

	Never Discussed (1)	Discussed Once or Twice (2)	Just Beginning to Discuss (3)	In the Middle of Discussion (4)	Discussed and Agreed to (5)	NA (6)
Methods to use when generating and processing data? (1)						
Data/material handling procedures both during and after data collection and analysis? (2)						
Publication venues? (3)						
Tools (e.g. software, equipment,						

247

etc.) to use during the course of your project (e.g. generating and processing data)? (4) Authorship order? (5)					

Table 0-8: Survey 2, collaborator discussions

Answer If TokenFunded Is Equal to 1

Q43 Did you hire an undergraduate student, a graduate student, or a postdoc to work on your project? (Check all that apply.)
- ❑ Undergraduate student (1)
- ❑ Graduate student (2)
- ❑ Postdoc (3)
- ❑ None of the above (4)
- ❑ Have not hired anyone yet (5)

Answer If Did you hire an undergraduate student, a graduate student... None of the above Is Selected Or Did you hire an undergraduate student, a graduate student... Have not hired anyone yet Is Selected Or Did you hire an undergraduate student, a graduate student... q://QID17/SelectedChoicesCount Is Equal to 0

Q44 Why have you not hired someone to work on the MCubed project?

Answer If Did you hire an undergraduate student, a graduate student... Undergraduate student Is Selected

Q45 Did you know the undergraduate student(s) before you received MCubed funding?
○ Yes (1)
○ No (2)

Answer If Did you know the undergraduate student(s) before you rece... Yes Is Selected

Q46 How did you know them?

Answer If Did you hire an undergraduate student, a graduate student... Graduate student Is Selected

Q47 Did you know the graduate student(s) before you received MCubed funding?
○ Yes (1)
○ No (2)

Answer If Did you know the graduate student(s) before you received ... Yes Is Selected

Q48 How did you know them?

Answer If Did you hire an undergraduate student, a graduate student... Postdoc Is Selected

Q49 Did you know the post-doc(s) before you received MCubed funding?
○ Yes (1)
○ No (2)

Answer If Did you know the post-doc(s) before you received MCubed f... Yes Is Selected

Q50 How did you know them?

Answer If Did you hire an undergraduate student, a graduate student... Undergraduate student Is Selected

Q51 Did you have any issues posting the position or hiring this assistant(s)?

❍ Yes (1)
❍ No (2)

Answer If Did you have any issues posting to hire or hiring this as... Yes Is Selected

Q86 What were the issues you had?

Answer If TokenFunded Is Equal to 1

Q52 When will your MCubed project have spent all of its funds?
[table of possible dates deleted to save space in print version]

Answer If Had you worked with any of your MCubed collaborators prev... Yes Is Selected

Q53 Has your project produced any preliminary findings or other progress towards your project's goals?

❍ Yes (1)
❍ No (2)
If No Is Selected, Then Skip To Have you received additional funding ...

Answer If Have you started work on your MCubed project yet? Yes Is Selected

Q54 Has your team prepared a conference presentation or manuscript based upon the initial progress of your MCubed project?

❍ Yes (1)
❍ No (2)

Answer If Have you started work on your MCubed project yet? Yes Is Selected

Q55 Has your team prepared a proposal for additional funding based upon the initial progress of your MCubed project?

❍ Yes (1)

❍ No (2)

Answer If Have you started work on your MCubed project yet? Yes Is Selected

Q56 Has your MCubed project been published or publicized in any other form? Please check all that apply.

❑ News articles (1)

❑ Press releases (2)

❑ Posters (3)

❑ Presentations (4)

❑ Blogs (5)

❑ Exhibitions (6)

❑ Online videos (7)

❑ Performances (8)

❑ Other (9) _____

❑ Please provide link(s) and/or titles if available (10) _____

Answer If Have you started work on your MCubed project yet? Yes Is Selected

Q57 Have you received any feedback from colleagues outside your project on the initial progress of your MCubed project?

❍ Yes (1)

❍ No (2)

Answer If TokenFunded Is Equal to 1

Q58 Have you received additional funding for your team to continue your MCubed project?

◯ Yes (1)

◯ No (2)

Answer If Have you received additional funding for your team to con... Yes Is Selected

Q96 How much funding did you receive and from what sources?

Answer If TokenFunded Is Equal to 1

Q59 How much longer will your MCubed project be active?

Answer If TokenFunded Is Equal to 1

Q60 When do you expect to complete your work?

[TABLE OF POSSIBLE DATES DELETED TO SAVE SPACE IN PRINT VERSION]

Q114 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.

❏ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1)

❏ Funding for brand new projects. (2)

❏ An additional source of funding for a project you had already begun working on. (3)

❏ Funding meant to support a project for its entirety. (4)

❏ Other, please specify. (5) _____

Q115 Overall, how would you describe your experience with the MCubed project to date?

Q116 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with?

Q117 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with?

Q118 If you have any additional comments or questions that have not already been covered in the survey, please enter them here.If you would like to contact the survey team directly, please email Professor Michael Traugott at mtrau@umich.edu. Once you are finished, please click the '>>' button to submit the survey.

Q143 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.
- ❑ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1)
- ❑ Funding for brand new projects. (2)
- ❑ An additional source of funding for a project you had already begun working on. (3)
- ❑ Funding meant to support a project for its entirety. (4)
- ❑ Other, please specify. (5) _____

Q144 Overall, how would you describe your experience with the MCubed project to date?

Q145 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with?

Q146 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with?

Q147 If you have any additional comments or questions that have not already been covered in the survey, please enter them here.If you would like to contact the survey team

directly, please email Professor Michael Traugott at mtrau@umich.edu. Once you are finished, please click the '>>' button to submit the survey.

Q148 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.

❑ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1)

❑ Funding for brand new projects. (2)

❑ An additional source of funding for a project you had already begun working on. (3)

❑ Funding meant to support a project for its entirety. (4)

❑ Other, please specify. (5) _____

Q149 Overall, how would you describe your experience with the MCubed project to date?

Q150 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with?

Q151 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with?

Q152 If you have any additional comments or questions that have not already been covered in the survey, please enter them here.If you would like to contact the survey team directly, please email Professor Michael Traugott at mtrau@umich.edu. Once you are finished, please click the '>>' button to submit the survey.

Mcubed Evaluation Faculty Survey 3

Final version deployed on October 1, 2014

Q1 Introduction This is a survey of research activity at the University of Michigan. This survey is part of a study being conducted by the Institute for Social Research at the University of Michigan with support from the Office of the Provost. Your participation in this study is voluntary. All responses will be anonymous and confidential and will be analyzed for statistical purposes only. Although you may not benefit personally from participation in this study, others may from learning the results. Reports from the results of the study will be made to the University community, but only in an aggregated form. If you have any questions about the study, you may contact the Behavioral Sciences IRB (http://www.irb.umich.edu/) or the principal investigator, Professor Michael Traugott, at mtrau@umich.edu. On average, it should take about 15 minutes to complete this questionnaire. Click on the arrow to continue to the next page.

Answer If PrevRespS1 Is Equal to no

Q5 What are the fields in which you were trained? Please list up to three.

Answer If PrevRespS1 Is Equal to no

Q115 What are your field specialties? Please list up to three.

Answer If PrevRespS1 Is Equal to no

Q116 Since your terminal degree, have you worked anywhere other than the University of Michigan?

❍ Yes (1)

❍ No (2)

Answer If Since your terminal degree, have you worked anywhere other than the University of Michigan? Yes Is Selected

Q117 Where did you work? Please check all that apply.

❏ Another academic institution (1)

❏ Private sector (2)

❏ Government (3)

❏ Other, please specify (4) _____

Answer If PrevRespS1 Is Equal to no

Q7 What is the highest level of education that you have completed?

○ Did not complete Bachelor's degree (1)

○ Bachelor's degree (2)

○ Master's degree (3)

○ Professional degree (M.D., D.D.S, J.D., etc.) (4)

○ Doctoral degree (Ph.D.) (5)

Answer If PrevRespS1 Is Equal to no

Q8 Overall, how many years of experience do you have as a researcher (not counting years as a student)?

Q11 Are you a member of a well-established research team? By this we mean a collaboration that has existed for one year or more, or has submitted research proposals together, or has coauthored papers together, or has produced another form of research product together. Please check all that apply.

❑ Yes, I belong to a well-established research team. (1)

❑ No, my research team cannot be considered a well-established one. (2)

❑ I am not a member of a single research team. Depending on the project, I work with different teams. (3)

❑ I usually work alone. (4)

Answer If Are you a member of a well-established research team?&nbs... Yes, I belong to a well-established research team. Is Selected Or Are you a member of a well-established research team?&nbs... No, my research team cannot be considered a well-established one. Is Selected Or Are you a member of a well-established research team?&nbs... I am not a

member of a single research team. Depending on the project, I work with different teams. Is Selected

Q12   Please give the number of collaborations or research teams you maintained during the last 3 years with…

Teams consisting of only University of Michigan researchers: (1)

Teams consisting of only American researchers other than you: (2)

Teams including at least one researcher from outside of the United States: (3)

Q28 Here are some statements about working with others. Please indicate the extent to which you disagree or agree with each one. If you come to a statement that does not apply to your situation, please mark 'Not Applicable' (NA).

	Strongly Disagree (1)	Somewhat Disagree (2)	Neither Disagree Nor Agree (3)	Somewhat Agree (4)	Strongly Agree (5)	NA (9)
There is a "sense of community" in my department. (1)						
Co-workers interrupt my work. (2)						
The people I work with treat me well. (3)						
The opportunity to talk informally with others is one of the reasons I enjoy my work. (5)						
Communications seem good within my department. (7)						

Table 0-9: Survey 3, working with others

Answer If Are you a member of a well-established research team?&nbs... Yes, I belong to a well-established research team. Is Selected Or Are you a member of a well-established research team?&nbs... No, my research team cannot be considered a well-established one. Is Selected Or Are you a member of a well-established research team?&nbs... I am not a member of a single research team. Depending on the project, I work with different teams. Is Selected

Q29   Next we would like to know about your general attitudes and satisfaction with your research collaboration(s). Please indicate the extent to which you disagree or agree with each statement. If you come to a statement that does not apply to your situation, please mark 'Not Applicable' (NA).

	Strongly Disagree (1)	Somewhat Disagree (2)	Neither Disagree Nor Agree (3)	Somewhat Agree (4)	Strongly Agree (5)	NA (9)
In general, collaboration has improved the quality of my research. (1)						
Collaboration benefits my career. (2)						
Other researchers in my field who do collaborative work are successful. (3)						
Collaboration is not common in my field. (4)						
Collaboration is useful in						

solving problems that are of interest to me. (5)					

Table 0-10: Survey 3, collaborative research

Q32 Here are some statements about interdisciplinary research. Please indicate whether you disagree or agree with each statement. If a statement does not apply to your situation, please mark 'Not Applicable' (NA).

	Strongly Disagree (1)	Somewhat Disagree (2)	Neither Disagree Nor Agree (3)	Somewhat Agree (4)	Strongly Agree (5)	NA (9)
It takes more time to produce a research article or product in an interdisciplinary research group (1)						
I have changed the way I pursue a research idea because of my involvement in interdisciplinary research. (2)						
Interdisciplinary research has improved how I conduct research. (3)						
I am optimistic that interdisciplinary research among collaborators leads to valuable research results that could not have occurred without that kind of collaboration. (4)						
Participating in an interdisciplinary team improves						

the research designs that are developed. (5)					
Generally speaking, I believe that the benefits of interdisciplinary research outweigh the inconveniences and costs of such work. (6)					
Interdisciplinary investigators as a group are open-minded about considering research perspectives from fields other than their own. (7)					
Publishing interdisciplinary research in my field can be difficult. (8)					
Interdisciplinary research works against people when it comes to tenure. (9)					

Table 0-11: Survey 3, interdisciplinary research

Q33   Thinking about your own experiences in the past, what barriers have you encountered when trying to establish research collaborations with investigators from other departments, institutions, or organizations?   Please check all that apply.

❑ Lack of time (1)

❑ Lack of funding (1)

❑ Lack of support staff to assist with collaborative research efforts (1)

❑ Limited awareness of opportunities to network with people outside my discipline (1)

❑ Lack of proximity to other researchers (1)

❑ Lack of interest among potential partners (1)

❑ Political or organizational pressures (1)

❑ Have not encountered any major barriers (1)

❑ Other (please specify): (1) _____

❑ Not applicable, never tried to collaborate (9)

Q34 The following items pertain to some of the thoughts and expectations you may have about your participation in research activities. Please indicate the extent to which you disagree or agree with each of the following statements. If you come to a statement that does not apply to your situation, please mark 'Not Applicable' (NA).

	Strongly Disagree (1)	Somewhat Disagree (2)	Neither Disagree Nor Agree (3)	Somewhat Agree (4)	Strongly Agree (5)	NA (9)
The research questions I am often interested in generally do not warrant collaboration from other disciplines. (1)						
In my collaborations with others I integrate research						

methods from different disciplines. (2)					
In my own work, I typically incorporate theoretical perspectives from disciplinary orientations that are different from my own. (3)					
Although I was trained in a particular discipline, I devote much of my time to understanding other disciplines in order to inform my research. (4)					

Table 0-12: Survey 3, research orientation

Q35   Please assess the frequency with which you typically engage in each of the activities listed below using the following seven-category scale.

	Never (1)	Rarely (2)	Once a year (3)	Twice a year (4)	Quarterly (5)	Monthly (7)	Weekly or more frequently (8)
Read journals or publications outside of my primary field. (1)							
Attend meetings or conferences outside of my primary field. (2)							
Participate in working groups or committees with the intent to integrate ideas with other participants. (3)							
Obtain new insights into my own work through discussion with colleagues who come from different fields or disciplinary orientations. (4)							
Establish links with colleagues							

from different fields or disciplinary orientations that have led to or may lead to future collaborative work. (5)							
Collaborate with researchers from my own discipline on developmental projects. (6)							
Collaborate with researchers from my own discipline in ways other than developmental projects. (7)							
Collaborate with researchers outside of my discipline on developmental projects. (8)							
Collaborate with researchers outside of my discipline in ways other than developmental projects. (9)							

Table 0-13: Survey 3, collaborative activities

Answer If TokenFunded Is Equal to no And PrevRespS1 Is Equal to no And PrevRespS2 Is Equal to no

Q36 Have you heard or read about a new initiative at the University of Michigan called the MCubed project?

○ Yes (1)

○ No (2)

○ Not Sure (3)

If No Is Selected, Then Skip To End of SurveyIf Not Sure Is Selected, Then Skip To End of Survey

Answer If PrevRespS1 Is Equal to no And PrevRespS2 Is Equal to no

Q37 What do you think MCubed is about?

Answer If Have you heard or read about a new initiative at the University of Michigan called the MCubed projec... Yes Is Selected

Q65 How do you view the funding provided as part of the MCubed initiative? Please check all that apply.

❏ Seed funding to begin work on an already planned project for which you hope to get further funding in the future. (1)

❏ Funding for brand new projects. (2)

❏ An additional source of funding for a project you had already begun working on. (3)

❏ Funding meant to support a project for its entirety. (4)

❏ Other, please specify. (5) _____

Answer If Have you heard or read about a new initiative at the University of Michigan called the MCubed pr... Yes Is Selected And TokenHolder Is Equal to no And PrevRespR1 Is Equal to no And PrevRespR2 Is Equal to no

Q109 Did you visit the MCubed website?

❍ Yes (1)
❍ No (2)

Answer If Have you heard or read about a new initiative at the University of Michigan called the MCubed pr... Yes Is Selected And Did you visit the MCubed website? Yes Is Selected

Q109b How did you use the MCubed website? (Select all that apply)

❑ Proposed my own project (1)
❑ Committed a token to someone else's project (2)
❑ Looked at other people's projects (3)
❑ Wanted to learn which individuals were participating in MCubed (4)
❑ Wanted to learn more about MCubed (5)
❑ Never logged in (6)

Answer If Have you heard or read about a new initiative at the University of Michigan called the MCubed pr... Yes Is Selected

Q100 Were you eligible to receive an MCubed token from your home academic unit?

❍ Yes (1)
❍ No (2)
❍ I don't know (3)

Answer If Were you eligible to receive an MCubed token from your home academic unit? Yes Is Selected

Q41 Did you request an MCubed token from your home academic unit so that you could participate in the MCubed project?

❍ Yes (1)
❍ No (2)

Answer If Did you request an MCubed token from your home academic unit so that you could participate in the... No Is Selected

Q42 Why didn't you request an MCubed token?

Answer If Have you heard or read about a new initiative at the University of Michigan called the MCubed projec... Yes Is Selected

Q101 Were you eligible to receive an MCubed token from any other academic unit?

❍ Yes (1)
❍ No (2)
❍ I don't know (3)

Answer If Were you eligible to receive an MCubed token from any other academic unit? Yes Is Selected

Q102 Did you request an MCubed token from any other academic unit?

○ Yes (1)

○ No (2)

Answer If Did you request an MCubed token from any other academic unit? Yes Is Selected

Q73 Which units were they?

Answer If Did you request an MCubed token from any other academic unit? No Is Selected

Q103 Why didn't you request an MCubed token from any other academic unit?

Answer If PrevRespS2 Is Equal to no And TokenHolder Is Equal to yes

Q4 How many projects did you contact to obtain additional information?

Answer If PrevRespS2 Is Equal to no And TokenHolder Is Equal to yes

Q5 How many projects did you contact about collaborating?

Answer If How did you use the MCubed website? (Select all that apply) Proposed my own project Is Selected

Q7 How many expressions of interest did you receive for your project?

Answer If How did you use the MCubed website? (Select all that apply) Proposed my own project Is Selected

Q8 How many did you invite to participate on your project?

Answer If How did you use the MCubed website? (Select all that apply) Proposed my own project Is Selected

Q164 How many of those you invited to participate agreed to collaborate on your project?

Answer If How did you use the MCubed website? (Select all that apply) Proposed my own project Is Selected

Q10 Were you able to form a Cube by getting at least two collaborators?
❍ Yes (1)
❍ No (2)

Answer If Were you able to form a Cube by getting at least two collaborators? No Is Selected

Q12 Why not?

Answer If How did you use the MCubed website? (Select all that apply) Committed a token to someone else's project Is Selected And How did you use the MCubed website? (Select all that apply) Proposed my own project Is Not Selected

Q11 Were you able to join a Cube?
❍ Yes (1)
❍ No (2)

Answer If Were you able to join a Cube? No Is Selected

Q13 Why not?

Answer If Were you able to form a Cube by getting at least two collaborators? No Is Selected

Q88 After you were unable to form a Cube, did you commit your token to a different project?

○ Yes (1)
○ No (2)

Answer If After you were unable to form a Cube, did you commit your token to a different project? Yes Is Selected

Q88a Was that project Cubed?

○ Yes (1)
○ No (2)

Answer If Was that project Cubed? No Is Selected

Q90 Why not?

Answer If PrevRespS2 Is Equal to no And TokenHolder Is Equal to yes

Q15 Was your project funded?

○ Yes (1)
○ No (2)

Answer If Was your project funded? No Is Selected

Q16 Do you know why you didn't receive MCubed funding?

Answer If Was that project Cubed? No Is Selected

Q70 Did you commit your token to someone else's project that was Cubed and funded?

○ Yes (1)

○ No (2)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q31 Did any collaborators drop out?
❍ Yes (1)
❍ No (2)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q37 How satisfied are you with your experience with MCubed to complete arrangements for your project?
❍ Very satisfied (1)
❍ Somewhat satisfied (2)
❍ Not at all satisfied (3)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q99 Please describe any problems you encountered with MCubed to complete arrangements for your project.

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q39 How satisfied are you with your experience with your home administrative unit to complete arrangements for your project?
❍ Very satisfied (1)
❍ Somewhat satisfied (2)
❍ Not at all satsified (3)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q100 Please describe any problems you encountered with your home administrative unit to complete arrangements for your project.

Answer If NumberCollaborators Is Not Empty And NumberCollaborators Is Greater Than 0

Q44 On the MCubed website, ${e://Field/Collaborator1} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator1} prior to agreeing to collaborate with him/her?

❍ Yes (1)
❍ No (2)

Answer If NumberCollaborators Is Greater Than or Equal to 2

Q45 On the MCubed website, ${e://Field/Collaborator2} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator2} prior to agreeing to collaborate with him/her?

❍ Yes (1)
❍ No (2)

Answer If NumberCollaborators Is Greater Than or Equal to 3

Q87 On the MCubed website, ${e://Field/Collaborator3} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator3} prior to agreeing to collaborate with him/her?

❍ Yes (1)
❍ No (2)

Answer If NumberCollaborators Is Greater Than or Equal to 4

Q88 On the MCubed website, ${e://Field/Collaborator4} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator4} prior to agreeing to collaborate with him/her?

❍ Yes (1)
❍ No (2)

Answer If NumberCollaborators Is Greater Than or Equal to 5

Q89 On the MCubed website, ${e://Field/Collaborator5} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator5} prior to agreeing to collaborate with him/her?

❍ Yes (1)
❍ No (2)

Answer If NumberCollaborators Is Greater Than or Equal to 6

Q90 On the MCubed website, ${e://Field/Collaborator6} was indicated as one of your collaborators, either currently or in the past. Did you know ${e://Field/Collaborator6} to agreeing to collaborate with him/her?

❍ Yes (1)
❍ No (2)

Answer If On the MCubed website, ${e://Field/Collaborator1} was indicated as one of your collaborators, ei... Yes Is Selected

Q46 How long (in years) have you known ${e://Field/Collaborator1}?

Answer If On the MCubed website, ${e://Field/Collaborator1} was indicated as one of your collaborators, ei... Yes Is Selected

Q48 Please check all the ways you have interacted with ${e://Field/Collaborator1}. Choose all that apply.
❑ Collaborated on a proposal (1)
❑ Collaborated on a research project (2)
❑ Collaborated on a performance, exhibition, or other creative output (3)
❑ Co-authored a conference paper, article, chapter, or book (4)
❑ Presented together (5)
❑ Co-taught a course (6)
❑ Departmental colleague (7)
❑ Interacted socially (8)
❑ Never interacted (10)
❑ Other, please specify (9) _____

Answer If NumberCollaborators Is Greater Than or Equal to 1

Q50 What were the major reasons you choose to collaborate with ${e://Field/Collaborator1} on an MCubed project? Choose all that apply.
❑ Collaborator has special competence. (1)
❑ Collaborator has special data or equipment. (2)
❑ Development and testing of new methods. (3)
❑ Social reasons (old friends, past collaboration, etc.) (4)
❑ Mentor/mentee relationship. (5)
❑ Other, please specify. (6) _____

Answer If NumberCollaborators Is Greater Than or Equal to 1

Q112 Please indicate how similar ${e://Field/Collaborator1}'s research field is to yours.
○ Same field, same subfield. (1)
○ Same field, different subfield. (2)
○ Different field. (3)

Answer If On the MCubed website, ${e://Field/Collaborator2} was indicated as one of your collaborators, eit... Yes Is Selected

Q47 How long (in years) have you known ${e://Field/Collaborator2}?

Answer If On the MCubed website, ${e://Field/Collaborator2} was indicated as one of your collaborators, eit... Yes Is Selected

Q266 Please check all the ways you have interacted with ${e://Field/Collaborator2}. Choose all that apply.
❑ Collaborated on a proposal (1)
❑ Collaborated on a research project (2)
❑ Collaborated on a performance, exhibition, or other creative output (3)
❑ Co-authored a conference paper, article, chapter, or book (4)
❑ Presented together (5)
❑ Co-taught a course (6)
❑ Departmental colleague (7)
❑ Interacted socially (8)
❑ Never interacted (10)
❑ Other, please specify (9) _____

Answer If NumberCollaborators Is Greater Than or Equal to 2

Q51 What were the major reasons you choose to collaborate with ${e://Field/Collaborator2} on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1)

❑ Collaborator has special data or equipment. (2)

❑ Development and testing of new methods. (3)

❑ Social reasons (old friends, past collaboration, etc.) (4)

❑ Mentor/mentee relationship. (5)

❑ Other, please specify. (6) _____

Answer If NumberCollaborators Is Greater Than or Equal to 2

Q63 Please indicate how similar ${e://Field/Collaborator2}'s research field is to yours.

❍ Same field, same subfield. (1)

❍ Same field, different subfield. (2)

❍ Different field. (3)

Answer If On the MCubed website, ${e://Field/Collaborator3} was indicated as one of your collaborators, eit... Yes Is Selected

Q91 How long (in years) have you known ${e://Field/Collaborator3}?

Answer If On the MCubed website, ${e://Field/Collaborator3} was indicated as one of your collaborators, eit... Yes Is Selected

Q267 Please check all the ways you have interacted with ${e://Field/Collaborator3}. Choose all that apply.

❑ Collaborated on a proposal (1)
❑ Collaborated on a research project (2)
❑ Collaborated on a performance, exhibition, or other creative output (3)
❑ Co-authored a conference paper, article, chapter, or book (4)
❑ Presented together (5)
❑ Co-taught a course (6)
❑ Departmental colleague (7)
❑ Interacted socially (8)
❑ Never interacted (10)
❑ Other, please specify (9) _____

Answer If NumberCollaborators Is Greater Than or Equal to 3

Q99 What were the major reasons you choose to collaborate with ${e://Field/Collaborator3} on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1)
❑ Collaborator has special data or equipment. (2)
❑ Development and testing of new methods. (3)
❑ Social reasons (old friends, past collaboration, etc.) (4)
❑ Mentor/mentee relationship. (5)
❑ Other, please specify. (6) _____

Answer If NumberCollaborators Is Greater Than or Equal to 3

Q108 Please indicate how similar ${e://Field/Collaborator3}'s research field is to yours.

❍ Same field, same subfield. (1)
❍ Same field, different subfield. (2)
❍ Different field. (3)

Answer If On the MCubed website, ${e://Field/Collaborator4} was indicated as one of your collaborators, eit... Yes Is Selected

Q92 How long (in years) have you known ${e://Field/Collaborator4}?

Answer If On the MCubed website, ${e://Field/Collaborator4} was indicated as one of your collaborators, eit... Yes Is Selected

Q268 Please check all the ways you have interacted with ${e://Field/Collaborator4}. Choose all that apply.

❑ Collaborated on a proposal (1)
❑ Collaborated on a research project (2)
❑ Collaborated on a performance, exhibition, or other creative output (3)
❑ Co-authored a conference paper, article, chapter, or book (4)
❑ Presented together (5)
❑ Co-taught a course (6)
❑ Departmental colleague (7)
❑ Interacted socially (8)
❑ Never interacted (10)
❑ Other, please specify (9) _____

Answer If On the MCubed website, ${e://Field/Collaborator4} was indicated as one of your collaborators, eit... Yes Is Selected

Q96 Please check all the ways you have interacted with ${e://Field/Collaborator4}. Choose all that apply.

❑ We have never interacted prior to the MCubed project. (1)
❑ We have worked on a prior project together, but did not work directly together or publish together. (2)
❑ We have previously submitted a proposal together. (3)
❑ We have previously presented or published together. (4)
❑ We have interacted socially. (5)

Answer If NumberCollaborators Is Greater Than or Equal to 4

Q100 What were the major reasons you choose to collaborate with ${e://Field/Collaborator4} on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1)
❑ Collaborator has special data or equipment. (2)
❑ Development and testing of new methods. (3)
❑ Social reasons (old friends, past collaboration, etc.) (4)
❑ Mentor/mentee relationship. (5)
❑ Other, please specify. (6) _____

Answer If NumberCollaborators Is Greater Than or Equal to 4 And Have you heard or read about a new initiative at the University of Michigan called the MCubed pr... Yes Is Selected

Q109 Please indicate how similar ${e://Field/Collaborator4}'s research field is to yours.

❍ Same field, same subfield. (1)
❍ Same field, different subfield. (2)
❍ Different field. (3)

Answer If On the MCubed website, ${e://Field/Collaborator5} was indicated as one of your collaborators, eit... Yes Is Selected

Q93 How long (in years) have you known ${e://Field/Collaborator5}?

Answer If On the MCubed website, ${e://Field/Collaborator5} was indicated as one of your collaborators, eit... Yes Is Selected

Q269 Please check all the ways you have interacted with ${e://Field/Collaborator5}. Choose all that apply.

❑ Collaborated on a proposal (1)
❑ Collaborated on a research project (2)
❑ Collaborated on a performance, exhibition, or other creative output (3)
❑ Co-authored a conference paper, article, chapter, or book (4)
❑ Presented together (5)
❑ Co-taught a course (6)
❑ Departmental colleague (7)
❑ Interacted socially (8)
❑ Never interacted (10)
❑ Other, please specify (9) _____

Answer If NumberCollaborators Is Greater Than or Equal to 5

Q101 What were the major reasons you choose to collaborate with ${e://Field/Collaborator5} on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1)
❑ Collaborator has special data or equipment. (2)
❑ Development and testing of new methods. (3)
❑ Social reasons (old friends, past collaboration, etc.) (4)
❑ Mentor/mentee relationship. (5)
❑ Other, please specify. (6) _____

Answer If NumberCollaborators Is Greater Than or Equal to 5

Q110 Please indicate how similar ${e://Field/Collaborator5}'s research field is to yours.

❍ Same field, same subfield. (1)

❍ Same field, different subfield. (2)

❍ Different field. (3)

Answer If On the MCubed website, ${e://Field/Collaborator6} was indicated as one of your collaborators, eit... Yes Is Selected

Q94 How long (in years) have you known ${e://Field/Collaborator6}?

Answer If On the MCubed website, ${e://Field/Collaborator6} was indicated as one of your collaborators, eit... Yes Is Selected

Q270 Please check all the ways you have interacted with ${e://Field/Collaborator6}. Choose all that apply.

❑ Collaborated on a proposal (1)

❑ Collaborated on a research project (2)

❑ Collaborated on a performance, exhibition, or other creative output (3)

❑ Co-authored a conference paper, article, chapter, or book (4)

❑ Presented together (5)

❑ Co-taught a course (6)

❑ Departmental colleague (7)

❑ Interacted socially (8)

❑ Never interacted (10)

❑ Other, please specify (9) _____

Answer If NumberCollaborators Is Greater Than or Equal to 6

Q102 What were the major reasons you choose to collaborate with ${e://Field/Collaborator6}on an MCubed project? Choose all that apply.

❑ Collaborator has special competence. (1)
❑ Collaborator has special data or equipment. (2)
❑ Development and testing of new methods. (3)
❑ Social reasons (old friends, past collaboration, etc.) (4)
❑ Mentor/mentee relationship. (5)
❑ Other, please specify. (6) _____

Answer If NumberCollaborators Is Greater Than or Equal to 6

Q111 Please indicate how similar ${e://Field/Collaborator6}'s research field is to yours.

❍ Same field, same subfield. (1)
❍ Same field, different subfield. (2)
❍ Different field. (3)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q52 Now thinking about your MCubed project, since you agreed to work on the project together, have you had regular communication with your MCubed collaborators?

❍ Yes (1)
❍ No (2)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q53 How often have you communicated with your MCubed collaborators?
- Never (1)
- Once (2)
- Monthly (3)
- Every other week (4)
- Weekly (9)
- Two or three times a week (5)
- Daily (6)
- As needed (7)
- Other, please specify (8) _____

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q54 How often have you had scheduled meetings with your MCubed collaborators?
- Never (1)
- Monthly (2)
- Every other week (3)
- Weekly (4)
- Two or three times a week (5)
- Daily (6)
- As needed (7)
- Other, please specify (8) _____

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q69 In your MCubed project, how often have you and your collaborators discussed the following aspects of your project? If you come to a statement that does not apply to your situation, please mark 'Not Applicable' (NA).

	Never Discussed (1)	Discussed Once or Twice (2)	Just Beginning to Discuss (3)	In the Middle of Discussion (4)	Discussed and Agreed to (5)	NA (6)
Methods to use when generating and processing data (1)						
Data/material handling procedures both during and after data collection and analysis (2)						
Publication venues (3)						
Tools (e.g. software, equipment, etc.) to use during the course of your project (e.g. generating and processing data) (4)						
Authorship order (5)						

Table 0-14: Survey 3, collaborator discussions

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q25 Which of the following coordination tools have you used? Check all that apply.

❑ Google Docs/Cloud applications (1)

❑ MBox/Dropbox/Cloud file storage (2)

❑ Other shared file repository (3)

❑ Project intranet/wiki/website (4)

❑ Project database (5)

❑ Other (6) _____

❑ None of the above (7)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q56 Whom have you hired to work on the MCubed project? Check all that apply.

❑ Hired an undergraduate student(s) (1)

❑ Hired a graduate student(s) (2)

❑ Hired a post-doc(s) (3)

❑ Other (7) _____

Answer If Whom have you hired to work on the MCubed project? Check all that apply.
Hired an undergraduate student(s) Is Selected

Q58 How many undergraduate students did you hire?

Answer If How many undergraduate students did you hire? Text Response Is Equal to 1

Q58a Did you know the undergraduate student before you received MCubed funding?

❍ Yes (1)

❍ No (3)

Answer If Did you know the undergraduate student(s) before you received MCubed funding? Yes Is Selected

Q58a1 How did you know them?

Answer If Whom have you hired to work on the MCubed project? Check all that apply. Hired an undergraduate student(s) Is Selected

Q58b Did you know those undergraduate student(s) before you received MCubed funding?
○ Yes, all of them (1)
○ Yes, some of them (2)
○ No, none of them (3)

Answer If Did you know those undergraduate student(s) before you received MCubed funding? Yes, all of them Is Selected Or Did you know those undergraduate student(s) before you received MCubed funding? Yes, part of them Is Selected

Q58b1 How did you know them?

Answer If Whom have you hired to work on the MCubed project? Check all that apply. Hired a graduate student(s) Is Selected

Q59 How many graduate students did you hire?

Answer If Whom have you hired to work on the MCubed project? Check all that apply. Hired a graduate student(s) Is Selected

Q59a Did you know the graduate student before you received MCubed funding?
○ Yes (1)
○ No (2)

Answer If Did you know the graduate student(s) before you received MCubed funding? Yes Is Selected

Q59a1 How did you know them?

Answer If Whom have you hired to work on the MCubed project? Check all that apply. Hired a graduate student(s) Is Selected

Q59b Did you know those graduate student(s) before you received MCubed funding?
❍ Yes, all of them (1)
❍ Yes, some of them (2)
❍ No, none of them (3)

Answer If Did you know those graduate student(s) before you received MCubed funding? Yes, all of them Is Selected Or Did you know those graduate student(s) before you received MCubed funding? Yes, part of them Is Selected

Q59b1 How did you know them?

Answer If Whom have you hired to work on the MCubed project? Check all that apply. Hired a post-doc(s) Is Selected

Q60 How many post-docs did you hire?

Answer If Whom have you hired to work on the MCubed project? Check all that apply. Hired a post-doc(s) Is Selected

Q60a Did you know the post-doc before you received MCubed funding?
❍ Yes (1)
❍ No (2)

Answer If Did you know the post-doc(s) before you received MCubed funding? Yes Is Selected

Q60a1 How did you know them?

Answer If Whom have you hired to work on the MCubed project? Check all that apply. Hired a post-doc(s) Is Selected

Q60b Did you know those post-doc(s) before you received MCubed funding?
- ◯ Yes, all of them (1)
- ◯ Yes, some of them (2)
- ◯ No, none of them (3)

Answer If Did you know those post-doc(s) before you received MCubed funding? Yes, all of them Is Selected Or Did you know those post-doc(s) before you received MCubed funding? Yes, part of them Is Selected

Q60b1 How did you know them?

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q51 Did you have any problems posting the position or hiring any assistant(s)?
- ◯ Yes (1)
- ◯ No (2)

Answer If Did you have any issues posting the position or hiring this assistant(s)? Yes Is Selected

Q86 What were the issues you had?

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

      N2 Have you expended all of your Mcubed funds?

❍ Yes (1)

❍ No (2)

Answer If Have you expended all of your Mcubed funds? Yes Is Selected

      Q52 When did your MCubed project spend all of its funds?

[TABLE OF POSSIBLE DATES DELETED TO SAVE SPACE IN PRINT VERSION]

Answer If Have you expended all of your Mcubed funds? No Is Selected

      Q327 When will your MCubed project have spent all of its funds?

[TABLE OF POSSIBLE DATES DELETED TO SAVE SPACE IN PRINT VERSION]

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

      Q55 Have you finished work on your MCubed project yet?

❍ Yes (1)

❍ No (2)

Answer If Have you finished work on your MCubed project yet? Yes Is Selected

      Q323 When did you finish it?

[TABLE OF POSSIBLE DATES DELETED TO SAVE SPACE IN PRINT VERSION]

Answer If Have you finished work on your MCubed project yet? No Is Selected

Q326 When do you expect it will finish?
[TABLE OF POSSIBLE DATES DELETED TO SAVE SPACE IN PRINT VERSION]

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q57 Have you received any feedback from colleagues outside your project on the initial progress of your MCubed project?

❍ Yes (1)
❍ No (2)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q53 Has your project produced any preliminary findings or other progress towards your project's goals?

◯ Yes (1)

◯ No (2)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q55 Has your team prepared a proposal for additional funding based upon the initial progress of your MCubed project?

◯ Yes (1)

◯ No (2)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q58 Have you received additional funding for your team to continue your MCubed project?

◯ Yes (1)

◯ No (2)

Answer If Have you received additional funding for your team to continue your MCubed project? Yes Is Selected

Q96 How much funding did you receive and from what sources?

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q84 Will there be or has there been at least one journal article about this project?

○ There already has been (3)

○ There will be (1)

○ No (2)

○ Don't know (4)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q113 Will there be or has there been at least one patent application based on this project?

○ There already has been (3)

○ There will be (1)

○ No (2)

○ Don't know (4)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q124 Will there be or has there been at least one performance based on this project?

○ There already has been (3)

○ There will be (1)

○ No (2)

○ Don't know (4)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q263 Will there be or has there been at least one conference paper based on this project?

○ There already has been (3)

○ There will be (1)

○ No (2)

○ Don't know (4)

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q89 Will there be or has there been some other product as the result of this project, such as data publications?

○ There already has been (3)

○ There will be (1)

○ No (4)

○ Don't know (5)

Answer If Will there be or has there been some other product as the result of this project, such as data pu... There already has been Is Selected

Q90 What was this product?

Answer If Will there be or has there been some other product as the result of this project, such as data pu... There will be Is Selected

Q90 What will this product be?

Answer If Was your project funded? Yes Is Selected Or TokenFunded Is Equal to yes

Q56 Has your MCubed project been published or publicized in any other form? Please check all that apply.

❑ News articles (1)

❑ Press releases (2)

❑ Posters (3)

❑ Presentations (4)

❑ Blogs (5)

❑ Exhibitions (6)

❑ Online videos (7)

❑ Other (9) _____

Answer If TokenHolder Is Equal to yes

Q62 Overall, how would you describe your experience with the MCubed project to date?

❍ Very satisfied (1)

❍ Somewhat satisfied (2)

❍ Neither satisfied nor dissatisfied (3)

❍ Somewhat dissatisfied (4)

❍ Very dissatisfied (5)

Answer If TokenHolder Is Equal to yes

Q63 What are the aspects of the MCubed process that you think have worked especially well to date or that you are especially satisfied with?

Answer If TokenHolder Is Equal to yes

Q64 What are the aspects of the MCubed process that you think have not worked especially well to date or that you are especially dissatisfied with?

Answer If TokenHolder Is Equal to no And PrevRespS1 Is Equal to yes

Q134 Have you heard or read about a new initiative at the University of Michigan called the MCubed project?

❍ Yes (1)

❍ No (2)

If No Is Selected, Then Skip To End of Survey

Q264 Do you think the MCubed project should be continued?

❍ Yes (1)

❍ No (2)

❍ Not sure (3)

Q265 If the MCubed project is continued, do you have any suggestions about how it can be improved?