Three Studies on Student Recruitment and Selection into Science, Technology, Engineering, and Mathematics Undergraduate Research Programs and Internships

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THREE STUDIES ON STUDENT RECRUITMENT AND SELECTION INTO SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS UNDERGRADUATE RESEARCH PROGRAMS AND INTERNSHIPS

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A thesis submitted to the Faculty of the School of Education of the University of Colorado in partial fulfillment of the requirement for the degree of Doctor of Philosophy.

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This thesis entitled:

Three Studies on Student Recruitment and Selection into Science, Technology, Engineering, and Mathematics Undergraduate Research Programs and Internships

written by Erik Keith Dutilly

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Abstract Page

Dutilly, Erik Keith (Ph.D, School of Education)

Three Studies on Student Recruitment and Selection into Science, Technology, Engineering, and Mathematics Undergraduate Research Programs and Internships

Thesis directed by Dr. Benjamin Kirshner

The U.S. government, including the National Science Foundation (NSF), makes significant investments in the upcoming generation of scientists and researchers through undergraduate research programs (UR) and internships. These programs are thought to motivate students to finish STEM degrees and provide authentic training under the mentorship of scientists. How are students recruited and chosen for these programs? This dissertation consists of three studies focusing on undergraduate student recruitment and selection into science, technology, engineering, and mathematics (STEM) undergraduate research (UR) programs and internships.

The first study is philosophical and proposes that gender should be considered a marker of merit in student selection competitions. The essay employs a Marxist feminists position to suggest that women, because of their historical exclusion from science and their oppressed social location, have special contributions to make to the scientific enterprise. The main feminist contribution is social epistemological. Women, under certain circumstances, can detect male biases in men’s conclusion, choice of theory and experimental design.

The second study looks at NSF’s UR program, called the Research Experiences for Undergraduates (REU). It sheds light on historical patterns of student recruitment and recruitment practices for eleven years of REU funding, 1987 to 2017. In line with federal priorities, individual REU sites have proposed recruiting undergraduate students who are members of underrepresented groups, and, additionally, students from groups that are not mentioned in the REU recommendations for recruitment (e.g., first-generation college students, low-income students). This study makes a contribution by documenting a taxonomy of student recruitment practices, something that will be useful to funders and practitioners.

The third study uses a discourse analysis approach to examine how two students were chosen for a summer internship in one department at a government laboratory in the Western United States. Findings show that the two students were selected for two reasons: one for how the internship could assist her career and the other for her potential contribution to the laboratory’s workload. Although diversity was part of the internship’s mission, it was not explicitly invoked during the selection deliberation. These studies contribute to scholarly understanding of undergraduate student recruitment and selection.
Acknowledgements

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Dissertation Introduction

This dissertation investigates and contributes to the scholarly literature on the topic of student recruitment and selection into science, technology, engineering, and mathematics (STEM) undergraduate research programs and internships. STEM undergraduate research programs and internships form part of the STEM opportunity structure, a term that refers to the expansive set of “co-curricular activities and programs…that support and enhance student participation in a STEM major, serve as pathways into STEM-related careers, or motivate student to pursue graduate school” (Figueroa, Hughes & Hurtado, 2013, p. 4). Undergraduate research programs and internships can take many forms. The specific programs highlighted in this dissertation are part of a family of apprenticeship experiences characterized by summer-long research or STEM-related work, traditional 40-hour a week work schedules in a university or government laboratory, close contact between undergraduate students and practicing science mentors, monetary compensation for the students’ time and effort, a requirement for a capstone presentation or paper, and additional recreational and social experiences for the students. In short, these programs allow student apprentices to practice authentic scientific activities in authentic locations alongside authentic science mentors (Laursen, Hunter, Seymour, Thiry & Melton, 2010).

Much of this dissertation focuses on undergraduate research and internships funded by the National Science Foundation (NSF). While probably unknown to most of the general public, the NSF generously funds undergraduate research in the sciences. For instance, in 2018, the NSF funded 700 distinct undergraduate research sites\(^1\) under its Research Experiences for

\(^1\) These are not all newly funded programs. Most REU sites are funded for three years. In any single year, there will be an assortment of programs at different stages of maturity.
Undergraduates (REU) funding stream. Each site has an average budget of around ninety thousand dollars to support, on average, eight student participants per summer. This sums to a sixty-three-million-dollar budget or $11,250 per student. This estimate excludes additional materials and equipment that REU sites request for research with the students. If the NSF REU program staff were asked why they provided such ample funding for undergraduate research in the sciences, they might answer in one of four ways or some combination of the four:

1) The REU program is mission driven. The REU program, its predecessor undergraduate programs, and other similar programs at the graduate level are instantiations of the purpose of the NSF as a government agency. One component of the NSF’s mission statement is “To promote the progress of science…”

2) The REU program provides benefits to the scientific community through investment in the next generation of scientists and researchers. The program strengthens the quality of STEM education through authentic engagement with real science. It also inspires underclassmen (e.g., first-year college students and sophomores) to pursue STEM careers and aspire to graduate school.

3) The REU program aims to reduce demographic underrepresentation in STEM fields. The REU program is part of the NSF’s portfolio of broadening participation programs.

4) The REU program is a funding stream for undergraduate research and undergraduate research in the sciences has been a social practice of the U.S. scientific community for more than a century.

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The study of student recruitment and selection has implications for all four of these answers. This dissertation touches most strongly on the third topic—broadening participation in the sciences or reducing demographic underrepresentation. Through philosophical inquiry and empirical study, these three articles touch on recruitment and selection of students from underrepresented groups.

In what follows, I summarize the research on the benefits of participating in undergraduate research programs to show that these programs are valuable experiences for students. Second, I provide a justification for research into student recruitment and selection that is grounded in prior research. Third, I broadly frame my understanding of research into recruitment and selection. Lastly, I provide an overview of the three articles.

**Research about Undergraduate Research Experiences for Students**

**Benefits of Participation**

In the past two decades, scholars have made enormous ground in documenting the learning outcomes for students who participate in undergraduate research programs and internships. A well-known outcome is the relationship between student participation in STEM undergraduate research and graduate school attendance (Bauer & Bennett, 2003; Russell, Hancock & McCullough, 2007). Bauer and Bennet (2003) found that for students who went on to complete a PhD, 67 percent had participated in an undergraduate research experience while only 12 percent of PhD recipients had not done any undergraduate research. In a survey study of alumni of a STEM biology undergraduate scholars program, Villarejo, Barlow, Kogan, Veazey and Sweeney (2008) similarly found that 83 percent of their sample reported that their undergraduate research experience influenced their decision to do research. In a survey study of nearly 15,000 students who had participated in one of several research experiences funded by the
National Science Foundation, Russell, Hancock, and McCullough (2007) found that 68 percent of their sample felt that the research experience had increased their interest in STEM careers either a lot or somewhat.

In addition to studying the connection between participating in an undergraduate research program and attending graduate school, scholars have studied other student learning gains. From 76 interviews conducted with undergraduate students who had participated in undergraduate research programs at four liberal arts colleges, Seymour, Hunter, Laursen and DeAntoni (2004) identified a set of five learning gains that students commonly reported on: personal/professional gains, thinking and working like a scientist, specific science skills, enhance career and graduate school preparation, and clarification and confirmation of career plans. The two most common categories that students reported on were (1) personal and professional gains and (2) thinking and working like a scientist (Laursen et al., 2010). When students discussed personal and professional gains, they mentioned aspects of personal growth such as increased self-confidence as well as growing their professional networks. Whey they spoke about thinking and working like a scientist, they consistently mentioned certain cognitive gains: acquiring knowledge, understanding the research process, and an increased ability to apply knowledge and skills to research problems.

Lopatto (2004) conducted a survey study that included 1,500 students across 41 institutions that had participated in undergraduate research experiences. He identified five claims that prior research and evaluation work had made about the impact of undergraduate research programs: (1) it enhances undergraduate education, (2) increases interested in STEM careers, (3) increases persistence in STEM degree programs, (4) increases graduate school attendance, and (5) more career clarification than students who do not have these experiences. He found that 87
percent of the participants reported positive experiences in their undergraduate research programs and over 83 percent reported a desire to attend graduate school. Only 3 percent of students had no plans for graduate school prior to their research experience and consequently decided not to pursue those careers. In aggregated form, the most commonly reported learning gains claimed by students were learning laboratory techniques, understanding the research process, tolerance for obstacles in the research process, and feeling ready for more demanding research experiences.

Findings like these and other literature reviews (see Laursen et al., 2010; Sadler et al., 2010; NAS, 2017) have helped to elevate undergraduate research programs to the status of “high impact educational practices,” which refer to undergraduate educational practices that improve student retention and learning outcomes (Kuh, 2008). Kuh (2008) reports that many universities are providing research experiences for undergraduate students during the school year and over the summer. University sponsored undergraduate research programs are commonly called Undergraduate Research Opportunities or UROPs.

**Justification for Further Research**

Although researchers have made significant inroads in documenting the learning gains associated with undergraduate research participation and advocated for its expansion into the undergraduate curriculum, some researchers have observed patterns in the kind of students who participate in undergraduate research programs. These students tend to be high academic achievers, highly motivated, and already have plans to attend graduate school in STEM programs. This issue became salient to researchers when they investigated student future career plans. Thiry, Laursen, and Hunter (2011) found that many of the students they interviewed did not dramatically alter their career plans after their undergraduate research experiences and a
large portion of their sample had already planned on applying to graduate school. Instead of changing students’ minds about STEM careers, undergraduate research appeared to reinforce their desire to go to graduate school.

Seymour et al. (2004) noted that there may be a bias in how professors select students. Professors may choose student apprentices based on perceptions of student traits that may predispose the students to become successful researchers and graduate students. Lopatto and Tobias (2010) wrote of this selection bias in detail. Just prior to this quote, the researchers had discussed the large number of students who participate in undergraduate research and plan to attend graduate school:

These numbers are impressive, but there is a confounding factor: selection. Undergraduate research opportunities have traditionally been offered to older students, juniors and seniors who already had declared a science major and who sought to enhance their credentials for graduate school applications. About 75% of the students who responded to my surveys were juniors or seniors. There is a second selection factor as well: most students beginning an undergraduate research experience already have the intention of going on in science. My survey data indicate that about 90% of students doing summer research have an existing plan to continue in science, and the plan did not change as a consequence of the experience. (p. 32)

They further noted that some program directors of undergraduate research programs feel that “allocating a research position to a student who has not pledged to go on in science is a waste of resource” (p. 32). In summary, patterns in student characteristics were the result of careful student selection by faculty. The careful student selection was a result of a moral belief that students who have plans to go in science fields were deserving of research positions.
These authors are not disparaging undergraduate research for students. Instead they are pointing out a potential confounding variable that throws into doubt one commonly repeated claim: that participation in undergraduate research experiences causes students to go to graduate school. In fact, it may be that the hiring or selection committees of STEM undergraduate research programs are choosing students who are predisposed to already intend to attend graduate school. While I do not investigate the technical question of how to parcel out prior student characteristics from the independent effect of undergraduate research participation on their career choices and interest in graduate school, this dissertation does examine what the process of selecting students looks like in practice.

Drawing on this literature review, I argue that the justifications and processes of selecting students for STEM undergraduate research programs and internships are a valuable area for scholarly inquiry. Although student selection may have a confounding effect on empirical claims about undergraduate research causing students to pursue graduate school, the exact processes and mechanisms are opaque. Knowledge gained from studying selection processes has the capacity to illuminate important empirical and normative questions. This dissertation makes progress towards investigating and considering philosophical arguments about recruitment and selection in STEM fields as well as descriptive research about recruitment and selection policies and practices.

Two Categories of Research on Student Recruitment and Selection

Broadly speaking, there are two kinds of concerns when it comes to studying recruitment and hiring practices in STEM undergraduate research programs and internships: normative and empirical. Normative questions are moral and debated in philosophical circles; empirical
questions are inquiries that are answerable through social science methods. In Figure 1 (below), I present a diagram to accompany this discussion.

**Normative**

Because of their general importance to structuring how people get jobs and students get undergraduate research and internship positions, it is difficult for people to avoid discussing what is the best or most ethical way to distribute these learning and training opportunities. All hiring practices, whether guided by affirmative action, meritocratic values, or a lottery system, have real consequences for applicants. The most basic way to think about it is that some people will get these positions and others will not and, as a result, their lives will be different in a counterfactual sense (compared to if the opposite outcome had occurred). Normative inquiries into hiring practices will ask questions like how ought we decide who does and who does not get hired? By what criteria? What exceptions can we make, if any? Is a defined distributional arrangement justifiable?

**Empirical**

I have already suggested some of the empirical dimensions previously but there are many more. Hiring practices are ubiquitous human social practices and they are important to people’s lives as well as how societies are organized. Recruiting and selecting students are practices used by every STEM internship and undergraduate research program that has more applicants than available positions. Empirical questions look at what these hiring practices are, the institutional or contextual forces that exogenously influence them, how people think about them, and what strengths and weaknesses particular hiring processes are perceived to have. Empirical studies collect facts and develop theoretical propositions about how student hiring operates.
Normative and empirical

Normative and empirical questions cannot always be disentangled, and researchers may see merit in combining the two. If a hiring practice produces patterned outcomes, one can ask if these patterned outcomes or the processes that produced them are just or justifiable. Normative studies will tend to start with a value-laden objective, such as determining if the strong patterning observed in hiring outcomes is fair for all applicants or just some. Blended normative and empirical concerns can be met in scholarly research by asking questions such as how can we change hiring practices to be better (in some way) or fairer (in some way)?

In the spirit of understanding both the normative and empirical dimensions of recruitment and hiring practices, and understanding them as equally valuable for academic inquiry, I
examined three aspects of the hiring practices. Each aspect of the hiring process roughly equated to an article in this dissertation. Taken together, it is my hope that these studies and inquiries break ground and inspire other scholars to become interested in what can be learned about the human condition from studying hiring practices in STEM undergraduate programs and internships.

Overview of Articles

Article 1. A Feminist Standpoint Argument for Gender as Merit in Undergraduate Research Program Admissions

Broadening participation refers to the National Science Foundation’s (2008) efforts to increase the presence of underrepresented demographic groups in STEM fields while also increasing the quality of scientific research and innovation. Because broadening participation entails significant investment of public resources, the arguments for and against it warrant careful assessment. The most promising justification for broadening participation is that doing so will strengthen the capacity of scientific communities to produce less biased findings and to enhance the capacity of scientific communities to develop innovative research. Employing arguments from feminist standpoint theory, I argue that the inclusion of women in scientific research in fields where they are underrepresented has and will continue to strengthen the United States scientific enterprise. The inclusion of women in science is a case study in how human diversity, and not just intellectual diversity (e.g., engineers with sociology backgrounds), is an asset that can be leveraged to reduce bias in scientific research. The original contribution of this article is to argue that members of selection committees for STEM training programs, such as undergraduate research programs, ought to consider gender as a kind of merit during student selection competitions. They should do so on the pragmatic grounds that training women in and
encouraging them to pursue STEM careers promises to increase the quality of STEM research in the future. After making the case for the inclusion of women in STEM fields where they are underrepresented, I conclude this paper by addressing a key objection that standpoint theory has little relevance to mathematics and some physical sciences where gender relations have little influence on the production of knowledge.

**Article 2. Broadening Participation in the Sciences: Examining Student Recruitment Proposals for the Research Experiences for Undergraduates Program**

Academics and politicians have been concerned with broadening participation in STEM fields. Yet there remains a need for information to guide practitioners and funders in recruiting individuals from underrepresented groups. This study contributes to the scholarship on broadening participation by examining one National Science Foundation funding stream—the Research Experiences for Undergraduates (REU) program. Using the thirteen revisions to the REU calls for proposals (CfPs) grant documents and the annually published REU awards abstracts, I examined four questions about undergraduate recruitment: (1) Which student demographic groups were recommended for recruitment by the NSF and what changes occurred in the recommendations over time? (2) Which student demographic were proposed for recruitment by REU sites? (3) What is the temporal association between (1) and (2)? (4) What were the most common recruitment strategies proposed by REU sites? Findings showed that student recruitment recommendations have diversified over time to include K-12 teachers, community college students, high school students, and U.S. veterans. The recruitment plans in the REU abstracts awards showed consistency in proposing to recruit from underrepresented groups, students with disabilities, women, and students from universities with limited research opportunities. While not a strong association, there is modest evidence that REU sites proposed
recruiting students from demographic groups introduced in the CfPs over time. The four most commonly proposed recruitment practices were recruiting from minority serving institutions, leveraging university partnerships, using broadening participation organizations, and using university diversity programs. Ideas for future studies on student recruitment are discussed.

Article 3. Need, Qualifications, and Diversity: Constructing Student Selection Criteria at One Federally Funded STEM Summer Internship for Undergraduates

Despite a growing interest in STEM undergraduate research programs and internships as mechanisms to enhance student learning and to increase student retention rates in STEM degree programs, little research has directly examined how students are selected or hired into these programs. Selection criteria, how selection criteria are weighted, the content of program mission statements, how committee members understand the purpose(s) of the internship, the background experiences of the selection committee members, and the particularities of a hiring context inform which and how students are chosen. In this paper, I examine the admissions process for one STEM summer internship at a government-funded laboratory in the Western United States, focusing on how the selection committee constructs meaning from the selection criteria and how these criteria constructions were applied to the students. Using a discourse analysis approach and Burke’s (1965) terministic screens as a conceptual lens, I examined transcripts of the deliberations of science mentors at two meetings discussing admissions. The mentors discussed the merits of three students competing for two summer internship positions. I argue that one student was admitted largely on the grounds of her perceived need for the internship and the second student based largely on her qualifications. Although student diversity was discussed by the committee, it played no obvious role as a selection criterion or consideration. The committee discussed the internship’s diversity mission in a defensive mode, employing legalistic terms.
Based on the literature review conducted for this study, this article may be the first discourse analysis on student hiring for STEM summer internships.
A Feminist Standpoint Argument for Gender as Merit in Undergraduate Research Program Admissions
Abstract

Broadening participation refers the National Science Foundation’s (2008) efforts to increase the presence of underrepresented demographic groups in STEM fields while also increasing the quality of scientific research and innovation. Because broadening participation entails significant investment of public resources, arguments for and against it warrant careful assessment. The most promising justification in favor is that it will lead to less widespread biases in scientific findings and will enhance the capacity of scientific communities to develop innovative research programs. Employing arguments from feminist standpoint theory, I argue that the inclusion of women in scientific research in fields where they are underrepresented has and will continue to strengthen the U.S. scientific enterprise. The inclusion of women in science is a case study in how demographic diversity and intellectual diversity are intertwined. The original contribution of this article is to argue that members of selection committees for STEM training programs, such as undergraduate research programs, ought to consider gender as a type of merit during student selection competitions. They should do so on the pragmatic grounds that training women in and encouraging them to pursue STEM careers promises to increase the quality of STEM research in the future. After making the case for gender as a merit selection category, I conclude by addressing a key objection: standpoint theory is not relevant to the production of knowledge in disciplines such as mathematics and some physical sciences.

Keywords: social epistemology, naturalized epistemology, feminisms of science, higher education, undergraduate hiring, undergraduate selection,
Among government agencies and within scholarly circles, there has been much discussion about the benefits and moral significance of increasing the demographic diversity in science, technology, engineering, and mathematics (STEM) fields, a project known as broadening participation (Blair, Miler, Ong & Zastavker, 2017; Erete, Martin, & Pinkard, 2017; Yoder & Mattheis, 2016). For example, the National Science Foundation (NSF) developed a framework for broadening participation in STEM fields (NSF, 2008). Arguments in favor of broadening participation have been forwarded in health and biomedical research arenas (Committee on Underrepresented Groups, 2010). Two government agencies, the NSF and the National Institutes of Health, have invested tens of millions of dollars in grants to broaden the participation of individuals who are members of underrepresented demographic groups in medical and STEM fields (James & Singer, 2016). For scholars who study distributive justice (e.g., Miller, 1999), these investments raise an important question: Why should public funds be allocated to broaden participation at all?

The most compelling reason to continue public investment in broadening participation is because human diversity is an asset that can be leveraged by scientific communities for preventative (exposing bias) and generative (producing new lines of inquiry) reasons.³ As argued by standpoint theorists, people from oppressed, non-dominant groups have an epistemic advantage in the production of scientific knowledge over people from dominant groups (Wylie, 2003, 2012; Harding, 1992, 2004). This advantage is a kind of developed capacity to critically assess dominant group research activity that more readily exposes bias in methodology, theory,

³ The debates around broadening participation parallel those of affirmative action in university admissions. Regarding this paper, diversity as an education benefit is the most closely related argument in affirmative action debates. Advocates of this rationale argue that selecting students for racial diversity, and other forms of diversity, will produce the best learning environment for all students. Gurin, Dey, Hurtando, and Gurin (2002) argued that the social interactions among diverse college students produces the educational benefits. My argument here differs in that I discuss an epistemic advantage that some members of underrepresented groups may have that creates a stronger scientific community. Both of these arguments treat human diversity as an instrumental good.
and the dominant group’s willingness to draw on and accept sexist or racist conclusions from data (Harding, 1992). The inclusion of persons from underrepresented groups in professional research increases the chances that these types of biases (e.g., sexism, racism) do not become intertwined in or have an influence in research. The reduction of biases, where biases are understood to be assumptions that inform theories and conclusions prior to data collection, is an aspiration of most if not all scientific communities (Anderson, 1995b). Researchers with developed standpoints are productive, not just critical, members of scientific communities. Once established in their careers, researchers from non-dominant groups have the potential to introduce new research questions and methodologies into the scientific fields (Intemann, 2009). Because their perspectives have been historically excluded from research, their research interests remain relatively unexplored.

To make the case why demographic diversity is an asset for scientific communities, I first discuss the current federal policy context around broadening participation in STEM fields to offer background on what underrepresentation is and why it is perceived to be a problem for scientific fields. Second, I review common justifications for broadening participation in STEM fields. Third, I offer an interpretation of the feminist standpoint position that argues for the epistemic advantage that women, when equipped with a feminist standpoint, have over men who tend to dominate many scientific fields. Fourth, given the feminist standpoint argument, I provide reasons why members of selection committees in undergraduate research programs should consider gender as a category of merit. Lastly, anticipating an objection, I argue that even

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4 In this essay, I use male/female and man/woman to account for most of the gender diversity among human beings. In part, this is because I am emulating the language that second wave feminists used to argue for standpoint theory. I acknowledge that there is more gender diversity in the world than only men and women. It is would be consistent with the argument developed here to expect that people who identify as gender non-conforming or non-binary also develop standpoints.
fields like mathematics and physics, where sexism or racism might appear to have no obvious bearing on the production of knowledge, are still at risk for bias when their professional communities are demographically homogenous.

**Federal Policy and Broadening Participation in STEM Fields**

Scholars and spokespersons for government agencies, such as the National Science Foundation, have identified underrepresentation of people of color, women, and persons with disabilities as a critical issue for STEM fields (Dasgupta & Stout, 2014; Jones, et al., 2016; Tibbetts, Harackiewicz, Priniski, & Canning, 2016; Ucko et al., 2016). These and other reports argue that the lack of demographic diversity in STEM fields represents vulnerability as well as opportunity. Demographic homogeneity is a vulnerability to STEM fields because white and Asian male workers, the traditional backbone of the U.S. STEM labor pool, may be numerically insufficient to fill the projected STEM labor demands. Viewed as an opportunity, groups that have been historically underrepresented in STEM fields are an untapped labor pool and could help to bridge the projected labor gaps. Some scholars have argued that demographic underrepresentation is a sign of structural or institutional barriers that have unjustly prevented members of underrepresented groups from accessing STEM fields (see Intemann, 2009). Unjust institutional barrier can be illustrated, for example, in the hypothetical case where a demographic group has had a lower quality K-12 educational experience that puts them on an unequal competitive playing field with students who have had stronger educational experiences.5

The term “underrepresentation” tends to be used in a particular way in STEM discourse. In STEM national and academic discourse underrepresentation tends to be to assess participation

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5 This educational difference is unjust in the sense that where students are born, not how intelligent or hardworking they are, causally influences their ability to compete for good jobs with students born in wealthier and better equipped school districts.
rates for members of certain demographic groups (e.g., Latinos) in certain fields of study (e.g., biology) or at certain educational levels (e.g., community colleges). A more complete term is national demographic underrepresentation, which I shorten to demographic underrepresentation.  

Demographic underrepresentation in STEM fields occurs for a sociodemographic group always and whenever its proportional share of a STEM field (e.g., undergraduate degree holders) is less than its proportional share of the national population. Demographic underrepresentation is often used by scholars and in government publications to highlight inequalities in rates of participation across demographic groups in STEM degree programs, scholarship programs, acquisition of federal grant funding, and participation in labor sectors.

The National Science Foundation (NSF) tracks demographic underrepresentation closely in educational and labor sectors and publishes a report biennially called Women, Minorities, and Persons with Disabilities in Science and Engineering (NSF, 2017). Two brief examples show how this definition of underrepresentation is used in practice (see NSF, 2017). In 2014, women comprised roughly 50% of the national population in the United States. In that same year, women made up only 20% of the bachelor’s degree holders in the field of physics, which made them underrepresented in terms of students who hold physics bachelor’s degrees. Also, in 2014, women comprised 58% of the bachelor’s degree holders in the biosciences, which made them slightly overrepresented as biosciences degree holders.

The bare facts of demographic underrepresentation provide little direction for policy proposals or traction for moral argumentation. Policymakers and STEM education reformers,

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6 National demographic underrepresentation is more complete and descriptive than simply “underrepresentation.” First, “national” signals that most federal government agencies in the United States are concerned with a population contained to its national territory. Second, “demographic” signals that underrepresentation attaches to human groups. However, even national demographic underrepresentation leaves out the implicit interest in groups that are overrepresented. Perhaps an even better, all-encompassing term might be national demographic representation, which does not privilege the modifiers “under” or “over.”
however, have invested these statistical patterns with inferences and drawn conclusions about the future of the U.S. STEM labor pool. Next, I review a few national and federal policy reports published in the last decades that drew inferences from demographic underrepresentation studies to recommend directions for federal policy. These reports are valuable to summarize because they provide insight into many of the mainstream concerns that have fueled interest in broadening participation. Many of these reports are also the jumping off points for most of the arguments or rationales that defend broadening participation.

In 2008, the National Science Foundation published a position paper on its broadening participation framework (NSF, 2008). The position paper established that NSF’s investments in reducing underrepresentation applied to three categories: individuals who are members of groups underrepresented in participation rates for NSF programs, institutions that were underrepresented in terms of receiving NSF grant funds, and geographic regions that were underrepresented in terms of receiving NSF funds relative to other geographic areas. The authors of the paper articulated that the goal of reducing underrepresentation was to increase the participation of individuals, institutions, and geographical regions that have historically received low levels of NSF funding or have had low rates of participation in NSF programs. The NSF argued that brilliant ideas and talented minds could be found anywhere in the U.S. and that broadening participation was a policy aimed at unearthing the talents of specific segments of the nation’s diverse population that had been overlooked.

In 2010, the National Academies Press, supported by numerous private foundations and government agencies including the National Science Foundation and the National Institutes of Health, published a report called Expanding Underrepresented Minority Participation (Committee on Underrepresented Groups, 2010). The authors of the report drew three
interrelated conclusions. First, historically, white and Asian males have been the main sociodemographic groups making up the STEM labor pool; recently U.S. institutions have been graduating more non-US foreigners in STEM degree programs. Second, domestically, underrepresented groups are the fastest growing demographic groups in the United States and can fill STEM workforce vacancies. Third, the diversity of underrepresented people is an asset in the sense that underrepresented people can contribute to the nation by “expanding the [STEM] talent pool, enhancing innovation, and improving the nation’s global economic leadership” (p. 3). The authors concluded that traditional demographic sources of the STEM labor pool (e.g., white and Asian males) were insufficient to meet projected labor demands and that underrepresented groups could fill the labor gap and invigorate technological and scientific innovation.

In 2012, the President’s Council of Advisors on the Science and Technology set out a series of policy proposals for increasing graduation rates in STEM fields (Olson & Riordan, 2012). The authors’ concern was that U.S. higher education institutions produced too few STEM graduates which threatened a STEM labor shortage. A focused investment in graduating more students from underrepresented groups could mitigate a labor shortage.

The White House STEM Education Strategic Plan echoed a similar labor concern: “Members of racial and ethnic minority groups are projected to become the majority of America’s population in the next 30 years. Currently, however, they account for only 28 percent of STEM workers” (Holdren, Marrett & Suresh 2013, p. 32). The White House STEM education report asserted that diversity of ideas and perspectives were an asset to “…the Nation as a whole” (p. 32).
There is a pattern in how these national reports raise and frame the problem of under-representation. Policymakers and practitioners who advocate for broadening participation in STEM are concerned that white and Asian men will no longer be able to sustain the growing demands of the STEM labor market. Other sources, for example a growing minority population, can bridge the labor gap. This concern has to do with the quantity of workers. A second issue raised by these reports pertains to the quality of the STEM labor workforce. As the international community competes for science global positioning, other countries present a threat to the United States’ position as a global leader in technology and science innovation and invention. According to this view, persons from underrepresented groups can contribute to STEM innovation, research, and problem solving and therefore contribute to the quality of STEM research and technological innovation. The arguments to follow provide support for how demographic diversity is an asset for the improvement of the quality of research in STEM fields.

**Common Rationales for Broadening Participation**

In the prior section, I reviewed broadening participation at the national level with special emphasis on government reports from major academic consortia and federal agencies such as the NSF. Here I shift to an analysis of the main rationales used among researchers and practitioners who study STEM undergraduate research programs and internships. These programs train undergraduate students in STEM research techniques with the intention of inspiring students to become STEM researchers or to pursue similar careers. Often these programs are designed so that undergraduate students apprentice under practicing scientists who also serve as mentors (Laursen et al., 2010). Although I found these rationales in the STEM internship and undergraduate research program literature, few rationales are specific to these programs. Many of the concerns mentioned in the undergraduate research literature echo national discourse.
The following articles were extracted from a review of dozens of peer-reviewed journal articles and book chapters. To locate these articles and book chapters I relied primarily on the Google Scholar search engine. I conducted a parallel literature search using the following terms as primary search stems and then adding a variety of modifiers to the primary search terms. The primary stem terms were (1) STEM internships and (2) STEM undergraduate research programs. To each of these I added a set of modifiers: diversity, broadening participation, minorities, women, Hispanics, Latinos, African Americans, Blacks, Native Americans, Pacific Islander, selection, and recruitment. After collecting these articles and book chapters, I reviewed the abstracts and bibliographies of the articles that were most on target with the topic and continued to deepen the literature review.

The two criteria of inclusion for this literature review were that the article presented (1) a rationale or statement regarding why it is imperative, valuable or morally correct to select students from underrepresented groups in STEM fields, and (2) it was on the topic of STEM internships or STEM undergraduate research programs. This procedure yielded a total of 55 articles and chapters that were then reduced to 48 after I applied the two selection criteria. I then organized these articles in a spreadsheet and created a short, annotated bibliography describing the essence of the broadening participation argument. As one moves from the national STEM policy reform to undergraduate research and internship literature, the scholarship base focuses less on developing strong arguments for broadening participating and more on referencing existing justifications in the national STEM literature. However, from reading these article and book chapters I gained a strong sense of the primary rationales for broadening participation that are present in the STEM undergraduate research and internship literature.
The rationales cited below are not the same as complete arguments that support broadening participation. Rather, they are common assertions used in STEM discourse and in scholarly work to motivate empirical studies.

**Labor Shortage Rationale**

This view argues that minorities, women, and persons with disabilities need to be trained in STEM fields because the U.S. is approaching a STEM labor shortage. Because of their historic underrepresentation, underrepresented groups can supplement the labor pool. White and Asian men, who have historically dominated STEM fields, will be numerically insufficient (Carpi et al., 2016; Conrad et al., 2016).

**National Parity Rationale**

An appeal to representational equality, this rationale asserts that the appropriate portion of any sociodemographic group in STEM fields where the demographic proportion in STEM fields and careers matches their portion of the national population. This is what is meant by parity. Parity applies equally to all levels of the STEM pipeline: from K-12 participation in afterschool science programs to university faculty positions. Parity is usually reserved for the national population and not, for example, global representation or for foreign-born students (Chemers et al., 2011; Hernandez et al., 2002).

**Global Competitiveness Rationale**

By including members of underrepresented groups in STEM fields, the United States’ global position in science and engineering can be strengthened. The exact metrics that make up the ideal STEM global competitiveness composite index are open to debate. One of the metrics

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7 The “STEM pipeline” is a metaphor that signals a hypothetical trajectory along which people travel from being students to professionals in STEM fields. This metaphor has been challenged and a “pathways” metaphor offered to replace it. The STEM pathways metaphor offers the advantage of acknowledging a multiplicity of ways that people move toward STEM professions beyond a single “pipeline” (see Cannady, Greenwald & Harris, 2014).
may be as simple as the number of engineering undergraduate students who graduate annually (Guessous et al., 2013; Shurn, Hardnett, & Kearse 2008).

Untapped Talent Rationale

Individuals from underrepresented persons have not had sufficient opportunity to demonstrate their talent in STEM fields. An underutilized group of people, the STEM community would benefit from including them in STEM training programs to develop and polish their talents. A background assumption of this rationale is that the general distribution of talent and intelligence for all sociodemographic groups is roughly similar such that all sociodemographic groups have highly talented individuals who could excel in STEM fields (Eagan et al., 2013; Summers & Hrabowski III, 2006).

In terms of justifying public expenditures on broadening participation, each of these rationales has some merit. People who defend the labor rationale are concerned with a shortfall of STEM workers. If a company cannot secure enough qualified workers, company officers may consider relocating somewhere with better labor prospects. An exodus of companies represents a loss of tax revenue and employment opportunity. Regarding national parity, large imbalances in demographic representation may be an indication of institutional inequalities that are structuring job opportunities along demographic lines, which expose worrisome gaps between the rich and poor or along race lines. Regarding national competitiveness, if the U.S.’s position as a global leader in STEM fields declines, then companies may choose to relocate where the climate for technological innovation is more fertile for innovation. Lastly, if demographic diversity is an important force behind technological and scientific innovation, then the U.S. could leverage its unique position as a highly diverse nation to maintain its global position as a leader in STEM research.
The commonality across these concerns is that persons from underrepresented groups in science fields can make valuable contributions to the STEM research enterprise in terms of numerical contributions to the labor force or by use of their unique talents. My thesis is that the most compelling contribution that persons from underrepresented groups can make is by their talents. First, I want to address the weaknesses of the labor and underrepresentation arguments.

Weaknesses in the labor and underrepresentation rationales. The labor argument depends on an empirically true gap between projected STEM jobs and the projected national population that will fill these jobs. If this gap exists, then it is possible for individuals from underrepresented groups to serve as a stopgap. On the other hand, there are other sources of people that can fill this gap. For one, it may be that policymakers interested in STEM labor shortages could recruit younger students more aggressively, irrespective of national representation status, and thereby increase the flow of students into the STEM pipeline. Second, under a more relaxed immigration climate, highly talented foreign students and already trained foreign workers could be recruited into the United States where they might prefer to live because of the high quality of life. Therefore, perhaps pushing for foreign STEM researcher visas is a wiser idea than investing millions of dollars into broadening participation programs. The weakness of the labor shortage rationale is that broadening participation is only one proposal among many for addressing labor shortages. If less expensive but equally effective options are identified, creating training programs specific for members of underrepresented groups may lose some of its appeal.

The national parity rationale suffers from a different vulnerability. It is difficult to ascertain the reason why underrepresentation is a problem without advancing an additional argument beyond presenting facts about demographic underrepresentation. For instance, that
women are underrepresented in terms of the annual distribution of physics doctoral degrees may not be inherently good or bad for physics, even if it is an inequality. Furthermore, it is unclear if it would be good or bad if the distribution of physics doctorates was gender-wise equal. The national parity rationale assumes an egalitarian position, that equality in distribution of physics doctorate degrees is better than inequality. But why would this be so? Why not, for instance, accept equality in terms of who is allowed to attempt a physics doctorate degree but not on who acquires one (see Arenson, 2013 on equality of opportunity)?8 Too much attachment to equality of outcomes and indifference to equal treatment of persons may have negative consequences, such as policies that punish institutions that do not graduate equal numbers of women and men or a reduction in standards for lower achieving individuals to ensure equal graduation rates. Defenders of the national parity argument must say more about their egalitarian position.

The position I defend, that persons from underrepresented groups are an asset to scientific fields, is on surer footing than the labor and underrepresentation rationales. First, if the argument is successful, it provides a reason to demographically balance scientific fields regardless of labor cycles. That is, I understand persons from underrepresented groups to be contributors to the production of scientific knowledge in ways that members of dominant groups (i.e., members of overrepresented groups) cannot. Second, I see demographic underrepresentation as instrumentally, not intrinsically, important unlike defenders of the national parity rationale. Demographic underrepresentation is an indicator of potentially undetected and entrenched biases in a scientific field. I do advocate for an equal distribution of men and women in scientific fields.

8 In a set of famous essays on equality, Dworkin (1981a, 1981b) explored the tensions between an equal distribution of welfare and an equal distribution of resources. One conclusion was that these two kinds of equality were in tension because the same set of resources may not produce equality in welfare because people can be roughly equally happy with different kinds and quantities of resources. That is, equal resource distribution may not lead to equality of welfare and equality of welfare may require unequal resource distribution.
Rather, the goal of my proposal is to move toward demographically balancing the scientific community in such a way that biases in the production of knowledge are surfaced, examined, criticized, and repaired.

**Core Tenets of Feminist Standpoint Epistemology**

In this section, I draw on feminist standpoint theory to make an argument for why women are likely to develop a unique epistemic advantage. I understand a feminist epistemic advantage to be a feminist perspective that some women develop over time that informs how they conduct scientific inquiry that is distinct from the way men, on average, look at scientific inquiry. It is a way of looking at and understanding the importance of the social processes that are part and parcel of the scientific production of knowledge and taking seriously where gender may play a meaningful role in knowledge production.

As forwarded by Wylie (2003) and Harding (1992), the feminist epistemic advantage arises through a collective process of critical self-reflection on women as members of an oppressed group that live in a patriarchal society. By virtue of being an oppressed member of society, women can come to occupy standpoints that provide them with the resources to make critical observations of a research process that produces oppressive gendered knowledge and permits them to inquire into feminist lines of research that may not interest men or be possible for them to accomplish. By including gender as a merit category and training women to be researchers, scientific communities stand to gain a truer understanding of human social relationships and power dynamics that causally influence the scientific research process.

Feminist standpoint theory has three core tenets (Wylie, 2003, 2012; Anderson, 2017; Intemann, 2010). The first is that the production of knowledge is socially situated. The producers of scientific knowledge are inescapably intertwined in that knowledge’s production. Second,
marginalized people, those who are excluded from the production of knowledge or oppressed through knowledge production, have an epistemic advantage over the oppressor group. Through achieved standpoints, marginalized people can offer insights that shed more objective light on the scientific process that produced oppressive knowledge about them and other oppressed groups. Third, the production of knowledge, especially about social relations and power dynamics, ought to begin from the lives of marginalized people. Beginning from the lives of marginalized people is a surer way to acquire truth about social relations.

Combining and emphasizing these three tenets produces valuable hypotheses about the production of scientific knowledge. Take, for instance, the tenet that all knowledge is socially situated (Harding, 1992). Knowledge can be understood as socially situated in numerous ways. It can be dated to a historical period, reflecting mainstream beliefs of a different century. It can be socially situated in that it was produced mainly by communities of men and reflects a masculine research agenda. It can be socially situated in the sense that demographic groups undergo and live through structurally different experiences over meaningful periods of time (e.g., Jim Crow era, female disenfranchisement). This tenet is in tension with the ideas that scientific knowledge can be universally true and that knowing about the producers of the knowledge is irrelevant to knowing anything useful about the fruits of scientific inquiry (Reiss & Sprenger, 2017).

If one combines the first and second tenets of standpoint theory, it is possible to assert that the social location (e.g., gender, class, race), on the feminist account, may play a causal role in the production of scientific knowledge. The social location of a person, their experiences in terms of who they are and how they experience life, inform how they think about empirical matters. This second tenet asserts that marginalized people have an epistemic advantage over non-marginalized people. Their marginalization, their exclusion from the production of
knowledge or silencing of their protesting voices, which is a kind of marginalized social location, situates them in such a way that they can offer insights into the scientific process that are unobvious to the non-marginalized groups. This is likely to be especially true when the non-marginalized group generates scientific knowledge about the marginalized or excluded group. Histories of science abound with case studies showing that dominant groups, those in control of the means of production of knowledge, wielded unjustified racist and sexist theories and assumptions about the people they studied (see Gould, 1981, for a study in the history of psychological testing).

The third tenet, that research should begin from the perspective of marginalized groups, serves as a methodological tactic for how to study social relationships and power dynamics. While, in principle, one could study gender relationships by asking men how they understand the division of household labor, feminist standpoint theorists argue that members of marginalized groups (i.e., women) would have an epistemic advantage on this topic (Wylie, 2003). In the case of the division of household labor, in societies where women are charged with intimate family member care (e.g., case of sickness, cleaning, child care) they have more experiential knowledge about how the man’s behavior and attitudes affect the household. In feminist thought, this is sometimes referred to as bifurcated consciousness (Smith, 1990). This capacity for thought develops in a woman as she considers her personal situation, which is common to many other women, and the patriarchal situation to which she must adapt to survive and flourish within a sexist society. Bifurcated consciousness is one way to understand the epistemic advantage of the woman over the man when it comes to knowing about gendered division of household labor.

One of the central problematics of the feminist intellectual movement has been to explain how a supposedly methodologically sound science could produce or reify sexist and racist ideas
(Anderson, 2017; Wylie, 2012). As social epistemologists, feminist standpoint theorists have answered that the composition of the scientific community itself bears much of the responsibility for the production of sexist and racist knowledge that continues to oppress and harm marginalized groups (Code, 1996; Harding, 2004). Excluding marginalized people from the process of scientific inquiry will increase the chances of biased research and reduce access to new lines of inquiry and research questions.

Because my thesis is that demographic diversity can be leveraged as an asset for the production of scientific knowledge, I now turn to carefully exploring the nature of the feminist standpoint as an epistemic resource that women may develop.

**Standpoints as Epistemological Resources**

In feminist standpoint thought, the idea of a standpoint is originally derived from the work of Georg Hegel and Carl Marx (See Hartstock, 1983 and Heckmen, 1997). Using two different examples, Hegel and Marx both argued that individuals from subordinate groups can acquire something like standpoints that give them an epistemological advantage over the dominant class when examining certain social phenomena (e.g., relative contributions to economic production, power dynamics). The object of knowledge for both theorists was the nature of the relationship between the oppressed and oppressor or a non-laboring class and a worker class. Hegel (1977) used the example of “lord” and “bondsman” (bondsman, here, indicates a person in bondage) while Marx (1977) conceived of the social world as split between the dominant capitalist class and the subordinate proletariat. For these theorists and feminist standpoint theorists, beginning research from the lives of marginalized people has the potential not only to reveal truths about the lives of the oppressed but also about the lives of the those who do the marginalizing. Marginalized people, they argue, have a broader perspective on issues of
oppression than the oppressor. For Marx, the subordinate or laboring groups gain objective knowledge into certain knowledge domains on the grounds that the laboring group is incentivized to understand social relations from their own perspective and from the perspective of the dominant class.

Feminists draw less from Hegel (1977) but when they do they discuss the section of his *Phenomenology of Spirit* where he illustrates his dialectical philosophy with the examples of the lord and the bondsman. As an idealist philosopher, Hegel was deeply interested in spirit and self-consciousness and his example of the lord and bondsman was not an overt political statement. However, the notion that feminists draw on is that in the struggle for unification with spirit, the bondsman, who labored for the lord, had a spiritual edge over the lord. This spiritual edge was that his dependence on and obligation to the lord forced him to engage in labor and aspire to freedom. The lord, Hegel concluded, lived for himself and therefore felt less of a need to strive. The important point for standpoint theorists is that despite the obvious status inequality between the two, the person in bondage, by aspiring to freedom, had a direction and purpose in life that pushed him or her toward more self-realization or deeper union with spirit.

The feminist interpretation on standpoints derives most closely from the writings of Karl Marx (1977) who studied and transformed Hegel’s dialectical philosophy. In contrast to Hegel’s emphasis on spirit and phenomenology, Marx’s historical materialism argues that the material conditions of life structure and determine the consciousness of both the ruling capitalist class and the proletariat. More than Hegel, Marx emphasized class division and conflict. Consciousness refers to the quality of self-awareness that human beings feel and the ways in which people define themselves. For Hegel, the struggles endemic to the human spirit gave rise (were expressions of) to material conditions of life while, for Marx, the material conditions of life...
determined the consciousness state of people. The influences of history and material life take
distinct forms for the proletariat and capitalist classes. For instance, the experiences of the
alienating effect of labor for the ruling class is, of course alienating, but comfortable and familiar
since the ruling class has helped bring this alienation into existence. In contrast, the proletariat
feel the crushing weight of the alienation of labor as it \textit{truly} is: a dehumanizing force upon
consciousness.

The proletariat’s possession of a standpoint assists them to see the reality of the alienation
of labor (Lukács & Lukács, 1971). This standpoint derives from the lived experience of being a
member of the proletariat, the economic underclass, whose labor is converted into profit for the
capitalist. The standpoints of the capitalist class and proletariat emerge distinctly because they
occupy two different positions or roles within the same economic system (Lukács & Lukács,
1971). The reason the two standpoints are not equally valid is because the ruling class tends to
assume that its values and accounts are the true accounts and misidentifies its interest-laden
values and accounts as universally objective. The standpoint of the proletariat offers a correction
for the ruling class and, noting the false objectivity, lays claim to a deeper objectivity over the
economic relations between them. This, in a nutshell, is how the subordinate class comes to have
more objective knowledge about social relations: The oppressed group sees the world from their
own perspective and understands the world from the view of the dominant group because their
livelihood and existence depend on and are non-trivially affected by the dominant group. Marx
and Engels (1970) asserted that consciousness or self-awareness arises out of the material
conditions of life, not the other way around.

Feminist standpoint theorists build on the Marxist analysis and apply it to gendered
relations in the social world (Cockburn, 2015; Harding, 1992). Men and women occupy different
positions within a patriarchal economic structure and the gendered division of labor is stark between women and men. On this view, women tend to be caretakers and men tend to produce goods for sale (Harstock, 1985). Men, like the ruling economic class, have little incentive to understand or see the world from the perspective of women and therefore omit the female experience from their analyses of social life. Their lives simply do not depend on it. Ignoring the needs and interests of women sets up a social situation where men become deaf to the oppression they purposefully or inadvertently create.

Because of this oppressive situation, women, like the proletariat, can develop a standpoint by virtue of their social location in the economic and social structures of a society. While men work to create and recreate the world as per their privileged social location, the world increasingly becomes a subordinating place for women. The feminist standpoint emerges from these conditions and becomes distinct from a “feminine perspective.” Bowell (n.d., section 5, para 2) explains:

Feminist standpoint theorists point out that, in order to survive within social structures in which one is oppressed, one is required to understand practices of oppression, to understand both oppressed and oppressor; but, this epistemic bi-polarity is neither required of, nor available to, the dominant.

By virtue of their particular oppressed position, women must see and understand social relationships, such as oppression and dominance, from a less erroneous perspective than the dominant class. Harding (1992) wrote, “Starting off research from women’s lives will generate less partial and distorted accounts not only of women’s lives but also of men’s lives and of the whole social order” (p. 56).
Although women may have privileged insight by virtue of their subordinate standing in a patriarchal society, turning this insight into an epistemic advantage requires effort and engagement with a feminist community. Grasswick (2016) wrote the following on achieving standpoints, “A standpoint does not naturally or automatically arise from a particular social location, although the experiences of an oppressed social location can make the achievement of a standpoint more likely” (p. 26). According to Grasswick, standpoints have two main features. The first is that they are earned or achieved and the second is that they require an oppressed social location. On Grasswick’s understanding, it is very unlikely if not impossible for an individual from a dominant or unoppressed group to achieve a standpoint. As women recognize their oppressed status and discuss it with other likeminded women, they begin to occupy standpoints. In feminist practices, the process of growing to occupy a standpoint is known as consciousness raising. Collective consciousness raising is an integral part of achieving standpoints and a feminist social-political practice. Consciousness raising is how an individual woman’s sense of oppression can be transformed into a socially recognized form of oppression (e.g., moving an uncomfortable experience at work toward insights about workplace sexual harassment).

As an epistemological resource, feminist scholars with achieved standpoints will contribute to a field’s body of knowledge in two ways (Anderson, 2017). The first is through a critical, deconstructive approach – what I referred to earlier as preventative. This is the phase of research where a field’s basic assumptions will come under feminist scrutiny and male biases will be surfaced and critiqued. The second phase is through a constructive or generative approach to building a research agenda. In this second phase, standpoint feminists will begin to
create a body of knowledge that complements what exists but from a feminist perspective that takes women’s issues as centrally important.

Feminist standpoint scholars do not assert that standpoints will always lead to new knowledge, valid critiques of a field’s implicit assumptions or corrections to a field’s dominant methodology. Wylie (2003) wrote that the thesis of epistemic advantage of marginalized or oppressed groups will exists in “at least some contexts” (p. 28). Anderson (2017) pointed out that for standpoint theories to be successful they must articulate how the epistemic advantage of a marginalized group arises within a context or domain. The tendency among feminists is to assert that epistemic advantage arises for marginalized people when the focus of the production of knowledge is on oppression, subjugation or social relations.

Up to this point, I have offered a theoretical account for the epistemic advantage that women with achieved standpoints have. Next, I provide examples from feminists who have made contributions to scientific fields.

**Feminist Contributions to Scientific Knowledge**

Moving from theory to practice in this section, feminist researchers have made numerous contributions to the social and natural sciences. Although I do not have space to provide an exhaustive treatment of all contributions, I mention a few to provide empirical support for the idea that feminist standpoints contribute to the production of scientific knowledge.

One well-known example in the feminist community comes from Carol Gilligan’s book, *In a Different Voice* (1982). Gilligan studied under psychologist Lawrence Kohlberg. Stemming from Jean Piaget’s pioneering studies in cognitive development, Kohlberg’s work theorized human moral reasoning as a developmental process that unfolded across the human lifespan. Kohlberg created a psychological scale that purported to measure human moral developmental as
occurring in discrete stage-like advancements over an individuals’ lifetime. He wrote that his scale applied equally to men and women and his findings tended to show that women reasoned morally at lower levels than men because men tended to use abstract principles from which to draw conclusions about ethical dilemmas. Abstract reasoning represented a higher rung on his stage theory.

Gilligan argued that Kohlberg’s scale was not universally generalizable to women and men. She noted several methodological flaws in Kohlberg’s model including that the first samples from which he generalized included mainly college-aged males and that the scale’s construction treated abstract hypothetical reasoning about justice as the highest stage of moral development. Valuing abstract reasoning above other kinds of reasoning favored the way men think about issues of justice. She ultimately questioned his conclusion that women consistently scored lower in moral reasoning than men and therefore were, on average, inferior to men in moral development. Gilligan’s research centered on developing a moral scale of development that considered feminine ways of moral reasoning which, she argued, are more relational and concerned with the care of others. She further argued that these feminine ways of understanding ethical dilemmas were not necessarily inferior to men’s moral reasoning.

A similar critique and revision was carried out in economics, where women’s contributions to the household economy have not always been noticed by the male-dominated field. From a feminist standpoint, Waring and Steinem (1988) argued that making women’s labor in the home invisible in formal econometric accounting and modeling was an act of keeping women “in their place” and leads to a misunderstanding of economic activity. Omitting women from economic calculations rendered their contributions invisible even though woman clearly
labor in the household and this labor enables the man to go to work longer than if he had to share in domestic labors.

In archeology, feminist researchers have made numerous constructive inroads, including, among others, working towards making visible the female contributions to ancient societies (Conkey, 2003). Prior to the inclusion of feminist studies of human history, women were largely represented as passive and of secondary interest to male activity, especially hunting (Wylie, 2012). Tools used by women went unrecognized in excavations. Gender issues and feminist topics can now be found in most introductory textbooks and encyclopedia entries on archeology.

Feminist scholars have been highly sensitive to the use of language and metaphor in scientific accounts of natural phenomena. In 1989, Donna Haraway wrote an influential book called *Primate Visions* in which she focused on the metaphors used by primatologists to describe male and female primate reproductive activity. She pointed out that male researchers tended to use certain descriptive metaphors and narratives. She also showed that female researchers will more often focus on collective activity and communication among apes. Martin (1991), a cultural anthropologist by training, used ethnographic methods to study numerous groups of reproduction biologists and found a puzzling inconsistency. For decades, mainly male reproductive biologists described the process of the unification of the male sperm and female egg in terms that suggested that the sperms were warrior-like and the eggs were passive receptors. Despite the observations made by the biologists that the egg played an active role in trapping and absorbing the sperm, the biologists in her study continued to use traditional sperm-as-warrior metaphors in their study write-ups. Although not a biologist herself, her work helped improve reproductive biology by identifying male biases present in scientific accounts of phenomena.
Feminist standpoint theorists might make several observations about these empirical studies. First, the absence of female researchers in these fields made possible the conditions under which male researchers, with their particular biases, could produce knowledge that either omitted or ignored female contributions to and perspectives on history, economics, psychology, and biology. The dominant biases and research directions went unchallenged.

Second, the addition of a female perspective into the research community was required to break new ground and challenge the ongoing production of knowledge that marginalized women’s mental capacities, contributions to economic activity, and contributions to social history. Gilligan challenged the idea that because women reasoned about moral dilemmas differently they were less morally developed. The cases of these female researchers are instructive because they appeared to start their research from a value-laden perspective: taking seriously women’s interests. Infusing their research with this and other values, they were able to make contributions to scientific inquiry (Anderson, 2004; Longino, 1990).

Lastly, and perhaps most important to the feminist standpoint perspective and the argument for social inclusivity in scientific research, the introduction of women into the inquiry process necessitated a change in the demographic composition of the scientific community. Understanding the scientific community as the locus of the production of knowledge is paramount to understanding how the diversification of standpoints within a scientific community is a necessary condition for checking dominant group biases (Intemann, 2010). Harding (1992) argued that scientific objectivity can be reframed as a property of the scientific community and one mechanism for continually assuring objectivity is by including a wide range of standpoints into the scientific inquiry process (e.g., gender, race, class).
Applying the Standpoint Argument to Undergraduate Research Program Admissions

I have argued that feminist standpoint theory offers resources for understanding the importance of diversifying the demographics of scientific communities. When they occupy standpoints, and are legitimate members of the scientific community, individuals from underrepresented groups (e.g., women) have the capacity to identify the biases of dominant groups, open new lines of scientific inquiry aligned with their group interests, and consequently improve the quality of scholarship produced by communities by intellectually strengthening those communities from the inside. But how should members of selection committees in undergraduate research programs understand the need for diverse standpoints?

Undergraduate research programs, especially when funded by government organizations, aim to strengthen the U.S.’s scientific research potential in two ways. The first is that they seek to inspire students to pursue STEM careers to supply research institutions and the STEM labor market with willing and capable candidates. The second is that these programs often have educative missions to train future generations of STEM workers in research skills.

While the feminist standpoint theory less directly addresses the first aim (the goal of increasing worker quantity), it directly addresses the need to increase the quality of the scientific community through the inclusion of women with standpoints. Feminist standpoint theory provides the resources for a complete and coherent understanding of the claim that people from underrepresented groups are an asset to the scientific community. It moves the discussion from an assertion that diversity is good for filling labor positions to a philosophical argument for the inclusion of diverse standpoints to strengthen the scientific community. It also provides a way to understand demographic underrepresentation as a problem. Demographic underrepresentation is
a sign that dominant group research interests and biases may operate unchallenged and therefore impoverish the quality of work produced by scientific communities.

The first reason selection committees should be interested in selecting women is because they are invested in the quality of the work produced in their fields. Moreover, it is troubling and oppositional to even traditional accounts of scientific objectivity that male biases may influence the production of knowledge.

A second reason it is valuable to treat gender as a merit category is because women must achieve some kind of a critical mass, however small, before they can begin to achieve standpoints (Intemann, 2010). On standpoint theory, admitting a single woman into a field will not accomplish the work outlined by feminist standpoint theory. Women must engage in consciousness raising about issues of oppression, sexism or the misrepresentation of women in their field of practice. The political activity of doing so requires many women, not just a single woman, focusing on and engaging in inquiry and consciousness raising. Standpoints are achieved through collective effort. Furthermore, not all women will achieve or strive to achieve standpoints.

Third, for women to appropriately contribute to their fields and gain intimate knowledge of their domains of study, they need practical and classical training in a field’s paradigms, methods, and grand challenges. Undergraduate research programs provide just such training opportunities. It is not necessary that undergraduate research programs and internships provide women with the seeds of a standpoint. It is more that these programs will provide women with opportunities to gain insider knowledge about a field at a faster rate than through a traditional university education. Once they understand the field’s inner working, they can raise constructive objections that push the field forward.
Lastly, internships and undergraduate research programs serve to bolster résumés and facilitate access to graduate school programs where women will continue their training and develop into researchers. Admitting women into these programs will make them more competitive for graduate school and consequently increase the probability that they will succeed as they climb the professional ranks. Although little to no empirical work on this exists, it is unlikely that standpoints are achieved by the undergraduate level. Most work cited by feminists were produced by women somewhat advanced in their research careers. Therefore, it seems reasonable to suspect that women need to be supported and encouraged in their career trajectories, especially in fields that have historically low levels of female representation.

In summary, undergraduate research programs and internships offer critical training along the STEM pipeline. While there is no guarantee that these programs will support the development of feminist standpoints, they can help young women gain intimate knowledge of a field’s methodologies and grand challenges. Additionally, they can augment a student’s resume and help that student get into graduate school. Effectively, these programs can assist in enabling women to move through the STEM pipeline which ought to help reduce underrepresentation in the STEM workplace. The place for a feminist standpoint to develop into a contribution to scientific study is at research institutions and participating in undergraduate research is an important stepping stone (National Academies, 2017).

**Criticisms of Feminist Standpoint Theory**

In this section, I address two criticisms. The first attunes to the applicability of standpoint theory to physical sciences and mathematics, where there is reason to suspect that feminist social epistemology may play almost no role in uncovering biases and providing new research agendas.
The second criticism is more pragmatic: How can selection committees identify female undergraduate candidates who are likely to occupy standpoints?

**Standpoint Theory and the Physical Sciences**

Before arguing against the criticism that feminist standpoint theory is not applicable to the “hardest” STEM fields (e.g., physics, math), I want to acknowledge that feminist standpoint theory has attracted critical attention from within and outside of feminist circles. According to some feminist accounts, feminist standpoint theory continues to operate at the margins of mainstream epistemology (Harding, 2004; Wylie, 2012). Briefly, feminist standpoint theory has been accused of reifying biological and cognitive differences between women and men, of an inability to persuasively argue that any one standpoint is epistemically more advantageous than any other (e.g., feminist standpoints are one standpoint among many other valuable standpoints), of ignoring intersectionality of complex and layered female social identities. Numerous good reviews of critiques exist, and my goal is not to detail the controversies but to provide an original critical consideration as it relates to the context of STEM undergraduate research programs (see Anderson, 2017; Harding, 2004; Heckmen, 1997; Intemann, 2010).

So far, the argument I made hinged on selection committee members seeing the value of standpoints in their fields and being willing to assist in reducing underrepresentation. Practitioners of undergraduate research, especially those charged with selecting students, should view gender as a type of merit and bring women into fields where they are underrepresented with the expectation that some of these women will develop standpoints and conduct research that identifies a field’s sexist or racist biases. Selection committee members will probably have to act without knowing which women will develop standpoints and which will not. They will have to admit many women.
One powerful objection to admitting women into undergraduate research programs on the standpoint account is that the achievement of standpoints is irrelevant to a field’s primary research. To many experts in STEM fields, particularly natural or physical scientists, standpoint theory may seem like a social science project with little utility for their field’s challenges. This objection has been suggested by feminist standpoint theorists (Anderson, 2017) and feminist empiricists (Intemann, 2010). For standpoint theorists, there are two problems raised here. The first is that the epistemic resources made available by occupying standpoints may not be well matched to a particular field’s challenges. Second, a field’s domain of inquiry may not provide the appropriate context for the activation of a standpoint. For instance, while women may identify sexism during faculty meetings in a mathematics department and develop standpoints as they collectively inquire into the nature of sexism, these standpoints are not well matched for offering a better understanding of calculus. Intemann (2010) wrote:

… it is difficult to see how oppressed groups would have an epistemic advantage in every epistemological context, as there are some areas of knowledge (for example, theoretical physics) where the experiences one has in virtue of one’s social position appear to be irrelevant to the content of the theories or evidence at stake (p. 784).

It is easy to generate a catalogue of examples of epistemological contexts for which standpoints of the oppressed will have little obvious advantage. Take for instance geologists who want to date precisely when the dinosaurs went extinct. Consider geomorphologists who study the causal factors that lead to the creation of self-organizing sand dunes in slow-moving streams. The central objection might be as follows: whenever scientists working in disciplines that study phenomena that have no obvious connection to social issues or the social world (e.g., planetary
rotation, light spectra), standpoints provide no relevant epistemic benefits for the production of knowledge.

I think this is a reasonable objection and I will offer four rebuttals to this objection. The first rebuttal is that the objection underestimates the feminist standpoint epistemological project. As a branch of social epistemology, standpoint theory shares the same overall objectives of other epistemologies: pointing out flaws in scientific methodology and proposing corrections. That is, just as an empiricist might worry about a confounding variable that was omitted from an observational study, feminist standpoint theorists worry about the social characteristics of researchers that may determine the social and cognitive processes underpinning the many background assumptions that characterize scientific inquiry. Feminists are concerned that the social process that produces scientific knowledge is infected with androcentric biases or exclusionary practices that ought to be corrected by a more diverse and inclusive scientific community that will identify and uproot these biases. There is no scientific field without a social process that leads to the production of knowledge (e.g., conferences, sharing of resources, peer reviewed journals) so it would appear that the standpoint project applies to all scientific fields. In the last few decades, sociologists of science have expended significant effort to describe how the social processes imprint on the production of scientific knowledge even in the natural sciences (Kuhn, 1996; Latour and Woolgar, 2012; Mulkay, 1972). In principle, any field with a social process underpinning its production of knowledge should be open to social epistemological critiques and the possibility that researcher gender is an important consideration.

The second rebuttal highlights the role that standpoint theorists can play in regular, everyday interactions in a university or workplace setting. For some fields, the empirical value of feminist standpoint theory will not be obvious. By this I mean that it will not seem obvious that
achieving a feminist standpoint is necessary for the direct discovery of scientific phenomena, such as biological species, subatomic particles or natural laws. But discovery is not the only activity that scientists partake of. The work of scientists consists of countless social interactions. Investing in women could have an important impact in departmental meetings, a field’s culture, social events, running research groups, search committees for faculty, seminars offered to graduate students, attracting diverse graduate students, and numerous other everyday events. Women with standpoints may help when men unfairly judge how a female professor candidate talks about her research based on her presentation style and when women struggle to raise valuable considerations in male-dominated laboratory groups due to gender-based intimidation. But without investing early in formative experiences for young women, the pool of women in some STEM fields will continue be low. If the pool of women is low, then those people who can occupy a standpoint and contribute to scientific communities will be even less.

Third, the previous rebuttals touched on the context of discovery of scientific phenomena or events. That is, the previous two rebuttals assumed a state of a scientific field where feminists were assisting with looking for or discovering natural phenomena. This is not the only paradigm for a scientific field’s operations. When certain fields have identified core challenges set within particular research paradigms, it may be the case that standpoints have little to contribute. For instance, if scholars within a field are currently preoccupied with refining measurements, standpoints may have little to add. If one removes oneself from inside such a paradigm, which may or may not have been androcentrically established in the first place, one may discover that women or other underrepresented people who occupy standpoints may push for an entirely different paradigmatic approach. Just as Dorothy Smith (1990) asked what the study of sociology might look like had it began from the feminine point of view, it is possible to wonder what new
and innovative angles might be discovered if the study of physics, math or statistics began anew from the perspective of standpoint feminists. What central problems might these modified disciplines begin with and what methods might be developed to answer these questions?

Fourth, recall that in the section titled “Feminist Contributions to Scientific Knowledge” I offered several examples of how feminist perspectives have shaken up and contributed to several scientific fields. Some feminists urged the experimental approach of including women in fields like physics on the grounds that it is difficult to know a priori what the contributions will be but that excluding feminist perspectives in the physical sciences may ultimately hamstring progress (Bug, 2003). Bug argued that several tenets of feminist theory may provide valuable resources for physics. For instance, in quantum mechanics research subjectivities can have a causal impact on experimental observations, a finding that collapses the observer/subject dichotomy. A tenet of standpoint theory is that knowledge is situated knowledge and bears the print of its producer (Harding, 1992). In other words, on the feminist account, it is incomplete to understand knowledge without a sense of who produced it and how the producers had an effect on its production. This is another way of looking at the collapse of the observer/subject dichotomy.

Thus, even in the seemingly impermeable core of the physical or “hard” sciences, there exists the possibility that the study and application of social epistemology may have a valuable role to play.

**Feminist Standpoint Theory and the Pragmatics of Student Selection**

A critic or a sympathizer of feminist standpoint theory could raise the objection that it is unclear how to choose women with emergent standpoints from an applicant pool.

This objection should not worry standpoint theorists any more than defenders of a strict educational meritocracy who must grapple with defining and then identifying merit in student
populations. But because selecting for standpoints is a noveler task than selecting for traditional merit (e.g., grades, test scores), I want to offer suggestions for how to proceed. First, because the development of a standpoint is a communal effort, more than one woman must end up in a research field. Selection committees will have to choose many women into their undergraduate research programs and internships. A second consideration is that these types of programs can prime the development of standpoints, not just select for them. Program designers and staff may consider optional readings or study groups on the topic of feminist science. Third, some women may signal their interest in developing a standpoint through certain combinations of double majors or majors and minors. A few relevant majors or minors are women’s studies, gender studies, critical theory or if the candidate took a class on feminist perspectives in science. Lastly, it is possible to develop essay questions that might provide clues as to which women are developing standpoints. For instance, an application essay question might ask all candidates how they understand the value of diversity in scientific fields.

Conclusion

In closing, the underrepresentation of women in STEM fields is a serious problem. It is not because STEM fields need more laborers or because underrepresentation is an inherently unjust distribution of STEM college degrees. Underrepresentation is a social epistemological issue that cuts to the core of the sciences. When fields are dominated by people from the same social category, certain biases will operate unchecked. The inclusion of people with standpoints in the production of knowledge is one way to move toward developing a more productive, less demographically lopsided, and more globally competitive STEM discipline. Feminist standpoint theory offers a strong theoretical account of the epistemic benefits of including people from
underrepresented group in scientific communities as well as empirical examples of where feminists have improved the state of scientific knowledge.

One of the important contributions of this article is that it moves the standpoint justification for broadening participation from an abstract theoretical plane into the working lives of STEM practitioners who operate undergraduate research programs and internships. Including young women into these programs (i.e., considering gender as a marker of merit) is an investment in the scientific community’s research future. The return on investment is that, once beginning their research careers, standpoint theorists will work toward identifying dominant group biases and offer useful and productive corrections that move scientific inquiry from male-centric biases toward a more ideologically balanced production of knowledge.
Broadening Participation in the Sciences:
Examining Student Recruitment Proposals for the Research Experiences for Undergraduates Program

Under review at the Journal of Women and Minorities in Science and Engineering
Abstract

There is a need for practical information to guide policymakers and practitioners to become more effective at broadening participation. This study contributes to the scholarship on broadening participation by examining the Research Experiences for Undergraduates (REU) program. This National Science Foundation (NSF) program recruits undergraduates from underrepresented backgrounds. Using the fourteen revisions to the REU Calls for Proposals (CfPs) and the REU awards abstracts between 1987 and 2013, I examined four research questions: (1) Using the CfPs, which student demographic groups were recommended for recruitment by the NSF and what changes occurred in the recommendations over time? (2) Using the awards abstracts, which student demographics were proposed for recruitment by REU sites? (3) Using the CfPs and awards abstracts, what is the temporal association between (1) and (2)? (4) Using the awards abstracts, what were the most common recruitment strategies proposed by REU sites? Findings showed that while persons from underrepresented groups have been consistently recommended for recruitment, NSF recruitment recommendations have diversified to include K-12 teachers, community college students, high school students, and U.S. veterans. The REU abstracts awards showed consistency in proposing to recruit from underrepresented groups, students with disabilities, women, and students from universities with limited research opportunities. There is modest evidence that REU sites proposed recruiting students from demographic groups introduced in the CfPs over time. The four most commonly proposed recruitment practices were recruiting from minority serving institutions, leveraging university partnerships, using broadening participation organizations, and using university diversity programs. Ideas for future studies on student recruitment are discussed.

Keywords: Diversity, Undergraduate Research Programs, Higher Education
1. Introduction

Two concerns are frequently cited in the literature on broadening participation in science, technology, engineering, and mathematics (STEM) fields. First, universities do not produce enough graduates to meet STEM labor market demands which could contribute to a labor shortage in U.S. STEM fields (Chubin, Harkavy & Martin-Vega, 2016; Ginther et al., 2009; Holdren, 2013). Second, U.S. global technological innovation could be aided by the addition of the untapped talents of traditionally underrepresented groups such as women, racial minorities, and community college students (Glass & Minnotee, 2010; Intemann, 2009; The National Academies Press, 2010).

To address these concerns, the National Science Foundation (NSF) has invested in programs to increase the presence of individuals, institutions, and geographical regions that have historically received relatively little NSF funding or have had low levels of participation in NSF programs. The NSF has also developed a formal policy position, known as broadening participation (BP), and delineated several strategies for reducing the underrepresentation of minority groups, geographic regions, and kinds of institutions (NSF, 2008). Since at least the early 1980s, the NSF included in its grant merit review criteria a series of recommendations that urged scientists to include persons from underrepresented groups in their research projects or in their outreach agendas (Holbrook, 2005). The NSF has a portfolio of broadening participation programs as well; the Research Experiences for Undergraduates program is one of these (James & Singer, 2016).

While there have been numerous publications on why broadening participation is a valuable objective for the scientific community (Intemann, 2009; The National Academies Press, 2010), less knowledge exists on how broadening participation policies translate into recruitment
and selection practices. Whether it be for promising proposals, programs targeting persons from underrepresented groups, or geographic regions that receive few resources from the NSF, recruitment and selection are part of the practical efforts that will accomplish the broadening participation agenda. This study focuses on the recruitment of undergraduate students from underrepresented groups.

The organization of the article is as follows. First, I discuss the NSF’s broadening participation agenda, distinguishing three often confused aspects. Next, I report on literature that shows the potential benefits of undergraduate research opportunities for students, with a focus on students from underrepresented backgrounds. Third, I discuss what is known about student recruitment into the REU program and undergraduate research programs in general. Fourth, I report the findings from this study. Fifth, after a discussion of the findings, I highlight a recommendation for how NSF REU proposal reviewers might improve the recruitment of specific demographic groups. Lastly, I propose future directions for studying student recruitment for the REU program.

2. Literature Review

Despite its size (nearly eight hundred REU sites were funded in 2017), its generous federal funding (an individual program can receive an award of around $80,000 for an eleven-week, eight-student summer program), and its history of aiming to recruit a diverse population (since its inception in 1987), there has been little systematic national-level research documenting REU student recruitment practices. Program evaluation has been largely the responsibility of individual REU program sites or NSF directorates. A literature search using Google Scholar and ERIC turned up only a handful of evaluation reports and scholarly publications. These reports varied in whether they evaluated the entire REU funding stream or looked at a single NSF
I begin this literature review with an overview of NSF’s position on broadening participation. Next, I discuss the scholarship on undergraduate research programs as a mechanism for retaining diverse students in STEM fields. Third, I report on what is known about student recruitment for the REU program.

2.1 Broadening Participation According to the National Science Foundation

This section of the literature review outlines three often confused aspects of the NSF’s broadening participation: broadening participation as a policy position, specific broadening participation programs or initiatives, and broadening participation as a part of the NSF’s grant review criteria. In 2008, the National Science Foundation (NSF) published a position paper on its broadening participation framework, which signaled its continued interest in working to reduce underrepresentation in NSF-funded research activities and programs (NSF, 2008). The NSF described what broadening participation meant, to whom and what it applied, and why it was a vital national project. The NSF typically limits its application of broadening participation to NSF-funded research activities.

As a position statement, the NSF’s broadening participation framework included three main categories to which broadening participation applied: individuals, institutions, and regions. Individuals are members of underrepresented groups (e.g., African Americans, women, Latinos) in STEM fields. The institutions targeted by the NSF are those that received limited NSF research monies (e.g., second and third tier research institutions). Lastly, the NSF included geographic areas of the United States that are underrepresented in terms of NSF research activities, grants, and programs (e.g., Alaska, Utah).
The operative word in the previous paragraph was “underrepresented,” which, in NSF’s terms means how some individuals, institutions or geographic areas have differential rates of participation in research activities compared to other individuals, institutions or geographic areas. This operationalization of broadening participation implies an empirical comparison across different sociodemographic groups, institutions, and geographic areas for how much research money or how many research programs the NSF funded in a geographic area. For example, some sociodemographic groups participate more in NSF-funded research activities and some geographical regions receive significantly more NSF grants than other regions. Underrepresentation is a conceptual tool to examine disparities.

The general goal of the broadening participation policy position is to move in the direction of equalizing the distribution of science research funds distributed by the federal government and away from highly concentrated resource distribution. Implicit in broadening participation is the normative idea that a more equal resources distribution is either better for science or fairer for the national scientific community. In addition to complying with certain federal laws (see NSF, 2008, p. 1), the reason the NSF sees this goal as desirable is that “Broadening participation…provides for the discovery and nurturing of talent wherever it may be found” (NSF, 2008, p. iii). One justification for broadening participation is that it is a commitment to developing domestic talent for the U.S. scientific and technology sectors. When discussing NSF’s broadening participation framework, it is important to keep in mind that it is geared toward excellence and inclusivity.

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9 Although there is no quantitative goal explicitly recognized by the NSF, the idea of under and overrepresentation leads me to suspect that there may be two ideal situations or final, acceptable distributional patterns. One is one where some groups of people, some kinds of institutions, and some geographic areas are equally represented in NSF funded activities. The second is where the representation of demographic groups, institutions, or geographic areas are represented in NSF activities equal to their national representation. That is, if R3 institutions are roughly X percent of all higher education institutions, they would receive that same percent of NSF funding.
Second, the NSF has translated its broadening participation policy into particular programs and initiatives. The NSF has funded numerous programs and created new funding streams to support broadening participation (James & Singer, 2016). For example, the Established Program to Stimulate Competitive Research (EPSCoR) program provides special funding programs for U.S. states that have received relatively little funding in the past (Feller, 2000; Wu, 2010). This particular NSF program seeks to broaden the participation of research institutions (institutions) in states (regions) that have been historically underrepresented in terms of how much NSF funding they have received. The REU program is a funding mechanism for undergraduate research that seeks to strengthen America’s scientific talent through expanding research opportunities to students (individuals) who are from demographic groups underrepresented in the sciences. It is important to note that NSF’s REU program is not a new kind of undergraduate research program, per se, but a funding stream that supports undergraduate research (UR) projects. What makes REU programs distinct from other UR programs are certain NSF programming requirements, such as teaching undergraduates about ethics in science research (although discontinued in recent years) or mandatory program reporting to the NSF. UR has been a long-standing practice in science (Laursen, Hunter, Seymour, Thiry & Melton, 2010; National Academies of Sciences, Engineering, and Medicine, 2017).

Third, broadening participation as an idea at the NSF predated the 2008 position paper (NSF, 2008). Beginning in 2007, grants submitted to the NSF were judged by two major components, the intellectual merit and broader impacts criteria (Holbrook, 2012). The broader impacts criterion requires grant writers to discuss what value or impact their work has for the good of society (Lok, 2010). For this review criterion, the NSF noted that one way to create a
broader impact in society through the funding of science is by broadening the participation of members of underrepresented groups. While it is true that the NSF has particular programs that seem clearly aligned with their broadening participation position (e.g., REU program), it is also the case that broadening participating has been consistently included in the merit review process prior to the funding of many BP programs and before the 2007 revision to the grant merit review process (Nadkarni & Stasch, 2013; Roberts, 2009).

2.2 Undergraduate Research as a Retention Strategy for Underrepresented Groups

In the previous section, I introduced NSF’s REU program as a funding mechanism for supporting UR in the sciences at a national level. The REU program is not, however, its own specific kind of UR program, but rather a funding mechanism to support apprenticeship undergraduate research (Laursen et al., 2010). Apprenticeship undergraduate research is when undergraduate students engage in authentic, ongoing research projects under the mentorship of a practicing researcher or scientist. While there are numerous learning gains that students make while doing UR (see Sadler, Burgin, McKinney & Ponjuan, 2010), the question I turn to is, what evidence supports the connection between UR and broadening participation?

Although recent times have seen a spike in scholarly research on UR programs, they have been a standard practice in science for more than a century. In an historical overview of undergraduate research programs, Laursen et al. (2010) found evidence that undergraduates have worked with professors on science research as early as the late 1800s. Regarding university UR programs, Merkel (2001) noted that the Massachusetts Institute for Technology had an undergraduate research program in 1969 and the California Institute for Technology began one in 1979.
What is new is that scholarship on UR has revealed numerous educational benefits for students. One commonly reported finding is that students who participated in UR also tended to go to graduate school (Bauer & Bennett, 2003; Russell, Hancock & McCullough, 2007). Although not an original purpose of UR, this research finding about graduate school matriculation offered evidence in support of leveraging UR to increase retention of undergraduate students in STEM fields, a significant priority of STEM pipeline advocates. Noting that UR is associated with retaining students in STEM fields, scholars interested in social justice and broadening participation began to see UR as a mechanism for broadening participation (Carpi, Ronan, Falconer & Lents, 2016; Conrad, et al., 2004; Villarejo, Barlow, Kogan, Veazey & Sweeney, 2008).

The existing evidence on the participation of persons from underrepresented groups in undergraduate research programs suggests that these programs can support them on their pathways toward finishing STEM undergraduate degrees and attending graduate school. Nagda et al. (1998) studied an undergraduate research program at the University of Michigan. Using an experimental design that randomly assigned similar students to either a control (no undergraduate research participation) or experimental condition (admitted to the undergraduate research program), they found that the students who participated in the research program had an attrition rate from their degree programs of only 11 percent compared to the control group which reported an attrition rate of 24 percent. This retention effect was highest for sophomore African American male students relative to Hispanic and White students. Using a survey design, Lopatto (2007) found that minority students had similar UR experiences to non-minority students in terms of helping clarify if the research profession was a good career for them. Villarejo et al. (2008) interviewed student alumni from a minority retention undergraduate research program at
the University of California-Davis. They observed that 96 percent of the alumni who obtained PhDs cited early research experiences as influential in their decision to pursue doctoral studies.

Laursen et al. (2010, see chapter 6) proposed two ways that UR may be responsible for positively influencing the STEM career tracks for minority students: by an amplification of benefits and through intentional UR program design. Amplification of benefits, so called because students from underrepresented backgrounds appear to gain more benefit than other student groups from the same intervention, may arise when UR experiences provide students who attended lower quality schools with an unusually rich learning experience compared to their prior schooling. The educational gains may be higher for minority students because of their disadvantaged starting point. Second, underrepresentation-specific programs, such as the Significant Opportunities for Atmospheric Research (SOARS), build in a series of program features on top of the research experience that target student motivation and research capacity. These may include financial aid for traveling to academic conferences, year-round monitoring of student academic progress, and addressing issues of race or gender. These additional program features may specifically help undergraduates from underrepresented groups overcome disadvantage.

Having shown that participation in UR holds potential benefits for all students as well as students from underrepresented groups in STEM fields, I now center the literature review on broadening participation through student recruitment for the REU program.

2.3 Recruitment Practices for Broadening Participation in the REU Program

The process of recruitment is when a company or organization undertakes concerted effort to generate an applicant pool from which they select finalist candidates for a job or position. Recruitment is a highly complex and skilled craft and, despite its important role in the
student hiring process, scholarship has been thin on recruitment practices for undergraduate research programs. While many researchers and evaluators who studied the REU program have focused scholarship on student learning gains, evidence from practitioner conferences suggests that UR program staff have called for more attention on recruitment (Chubin et al., 2017; Fealing & McNeely, 2016). Chubin et al. (2017) wrote the following in their summary of an NSF-funded conference on accountability and broadening participation:

“If there was unanimity on anything at the workshop, it is that the current approach to broadening participation must be reconsidered and reconfigured to recruit and nurture talent along many pathways, beginning in pre-Kindergarten (pre-K) and continuing into early careers” (p. 1).

While some scholars of UR have favored examining how UR programs lead students toward matriculating into graduate school (National Academies of Sciences, Engineering, and Medicine, 2017; Dahlberg et al., 2008; Laursen et al. 2010, see chapter 2; Russell et al., 2007), less is known about a logically prior step: what kinds of undergraduate students are recruited into UR programs and how is recruitment accomplished? Fortunately, some scholars have broken ground on this topic.

Fortenberry (1990) documented the recruitment strategies of REU sites during the first three years of the REU program’s existence, 1987 to 1990. From a survey of REU principal investigators who received REU awards, he learned that the two most common recruitment strategies were posting announcements in the REU program’s department and having fellow colleagues announce the research opportunity to their classes or lecture halls. Regarding recruiting underrepresented students, he wrote that the two most commonly used strategies were campus visits to universities and colleges that had high minority attendance and direct contact
with the students themselves. He did not discuss details of these strategies or what, if anything, made these strategies effective.

Beninson et al. (2011) surveyed REU grant recipients from the Biosciences REU programs. They found that the 2008 and 2009 REU principal investigators believed that their most effective recruitment strategies were using the internet (website and email), direct mails (letters, postcards), traditional media (flyers, magazines), conferences and networking, and campus recruitment offices. The authors also learned that undergraduate students identified specific REU programs through the NSF website, word of mouth from peers, from faculty members, and receiving a direct mailing from an REU site.

Although they did not study the REU program, Laursen et al.’s (2010) comprehensive book on STEM undergraduate research dedicated a section of a chapter to student recruitment into summer UR experiences at four liberal arts colleges. After analyzing interviews from UR faculty mentors and advisors, they argued that there were two major components to the student recruitment process: one formal and one informal. Formal processes governed efforts to bureaucratize the student recruitment process and make the UR opportunity widely known to undergraduate students. Staff in university departments made announcements for student recruitment and organized a centralized selection committee that sought to fairly distribute the perceived weaker and stronger students among participating faculty mentors. The informal process was a secondary recruitment process that occurred in parallel. The informal process was comprised of professors discussing certain student recruits with each other, sharing information on students with whom they had personal experience, and urging certain students to apply to the UR program. Laursen et al. (2010) pointed out that both the formal and informal recruitment processes offered certain advantages over each other’s shortcomings.
In the case of the REU sites, REU site managers and recruitment staff probably employ formal and informal recruitment strategies. It may be that the informal process describes recruitment internal to the host site because professors and advisors will have first-hand knowledge of students while recruitment outside of the host institution are influenced by formal systems. Because of the nature of the data analyzed in this study, I suspect that what I learn will pertain only to formal recruitment processes.

In summary, the literature review simultaneously established the importance of recruitment for REU programs and the paucity of scholarly knowledge on the topic. Many questions remained unanswered about student recruitment into REU sites. For instance, have REU sites been responsive to NSF’s student recruitment recommendations? What have been favored student recruitment strategies for REU sites? These questions are important because if the broadening participation policy agenda is to be realized, programs need to be responsive to it and they need to have successful recruitment strategies.

2.4. Significance of this Study

Despite the scope of the REU program and its historical legacy, few researchers have examined or evaluated it at a national level. The first major national study was published in 1990 (Fortenberry, 1990) and the second and last major study was published in 2006 (Russel, Hancock & McCullough, 2006). This study draws attention to the REU as a site worthy of investigation for the community of scholars studying undergraduate research. Moreover, because this study focuses on the practical, consequential, and annual activity of recruitment, findings may be of interest and relevance to program directors and funders, especially with regard to recruitment strategies. Lastly, other federal program officers outside of the National Science Foundation that manage large programs that are similar in nature and scope (i.e., broadening participation,
recruitment of undergraduates, national recruitment) stand to learn about recruitment strategies from this study.

3. Methodology

3.1 Research Questions

Table 2.1. Research questions and corresponding data sources.

<table>
<thead>
<tr>
<th>Number</th>
<th>Research question</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What sociodemographic groups were proposed for student recruitment and selection by the NSF in the fourteen REU Calls for Proposals (CfPs) released between 1987 and 2013?</td>
<td>CfPs</td>
</tr>
<tr>
<td>2</td>
<td>As the REU CfPs added new sociodemographic student categories between 1987 and 2017, is there evidence in the REU awards abstracts to suggest that REU sites targeted these new student groups?</td>
<td>CfPs &amp; REU Abstracts</td>
</tr>
<tr>
<td>3</td>
<td>As a counterpoint to question #2, from 1987 to 2017, did REU recruitment plans mention targeting students from groups that were not in any of the CfPs?</td>
<td>CfPs &amp; REU Abstracts</td>
</tr>
<tr>
<td>4</td>
<td>What are common student recruitment strategies that REU sites proposed?</td>
<td>REU Abstracts</td>
</tr>
</tbody>
</table>

3.2 Data Sources

I used two data sources to answer the research questions. The first was the published REU Calls for Proposals (CfPs). The REU CfPs are NSF documents that provide guidance to institutions that apply for REU funds. The documents contain detailed descriptions of the purpose of the program, the grant review process, and, most importantly for this study, recommendations for student recruitment and selection. The first CfP was written in 1987, the year the REU program began (Doyle, 1987). As of 2017, the historical archive of the CfPs consisted of fourteen documents, thirteen of which are revised versions of the 1987 original. The CfPs were published in 1987, 1990, 1993, 1996, 2000, 2001, 2002, 2003, 2004, 2005, 2007,
2009, 2012, and 2013. The CfPs are located on the NSF website and can be downloaded or viewed online. I obtained .pdf copies of all fourteen documents.\textsuperscript{10}

The second data source is a selection of eleven of thirty years from past REU awards, which spanned each year from 1987 to 2017. Each year contained the REU awards that NSF disbursed in that fiscal year. The REU awards abstracts are published periodically to the NSF website as individual projects receive official funding. Only funded REU projects have abstracts (NSF, NDa). Abstracts are paragraph-long summaries of the REU project and they are the public-facing documentation that both congress and the general public use to learn about the projects NSF funds (NSF, NDb). The goal of these abstracts is that an educated lay reader could read them, understand what the project is, and gain insight into why the NSF chose to fund it. The abstract may be written by an NSF program officer, the original proposer or both (NSF, 2018, pg. 93).

I included eleven years of the REU awards data in this study, which represented 33 percent of the thirty years. As a general rule, I opted to analyze the REU awards data year that occurred prior to each revision to the CfPs. Comparing the abstracts award data prior to the change in the CfP and after allowed for the possibility of observing an association between the introduction of new student demographic groups and changes in the REU awards proposal behavior.

To round out the data analysis and provide a better perspective of trends in REU recruitment proposals over time, I included the years 1987 and 1990 to gain a sense of the student recruitment proposal activity in the first years of the REU program. I also included an arbitrarily chosen year (2014) to mitigate the largest gap between the last CfP change (in 2008)

\textsuperscript{10} See appendix for National Science Foundation document numbers for each of the fourteen CfPs.

3.3 Data Coding

I used two data coding processes for the two data sources (see 3.3.1 and 3.3.2). The coding scheme included a combination of theory-driven and data-derived categories. For the theory-driven coding, I assumed that the demographic categories mentioned in the NSF’s Broadening Participation Framework document would appear in the data, which was true (NSF, 2008). However, upon reading hundreds of abstracts, I realized the theory-driven coding scheme was insufficient to account for the demographic diversity reported in the abstracts. As I encountered new demographic groups in the abstracts I included them in the coding scheme. This meant that I had to recode sections of the data due to the modified coding scheme. A full list of sociodemographic categories used in the CfPs analysis can be found in Figure 1.

3.3.1 REU calls for proposals documents.

The first step for coding the CfPs was to read through each of the fourteen documents to get a sense of their organization. The second step was to locate the sections that referred to student recruitment and selection. I did this by reading through the document, and by using keyword searches within the document (e.g., recruit, recruitment, select, selection, students, eligibility) to ensure that I did not overlook any references to recruitment, selection or student sociodemographic categories. Third, I constructed a spreadsheet with a master list of every student demographic category mentioned within the context of student recruitment and selection. Fourth, I noted for each year which student demographic groups were mentioned for recruitment and selection. For cases where a sociodemographic category was mentioned once, I marked only
the year that it appeared. For cases where a sociodemographic category was mentioned over several years, each year received a mark in the spreadsheet to show continuity.

3.3.2 REU award abstracts data.

For this study, the most important information in the abstracts were the project summaries, which are short paragraphs that described key aspects of the REU site. The abstract is the most concise summary of an REU program and is significantly shorter than an REU project summary. From the award abstract it is possible to learn about the proposed student recruitment and selection proposals. Because the abstracts are part of a grant proposal process, it is imperative to keep in mind that any recruitment information in this study related to student recruitment must be interpreted as proposals and not as actual activities or practices. Despite its limitations (see “Limitations” section), the advantage of using this data is that for any given year it contains some information about all funded REU projects. In part because of the shortness of the abstract and their public-facing nature, it may be that NSF program officers and REU grantees noted novel and interesting recruitment proposals (e.g., partnerships with universities) as opposed to mundane or obvious ones (e.g., using the NSF website).

Like the CfPs, the REU awards are available for download from the NSF website. I downloaded all REU awards from 1987 through 2017. I removed all duplicate awards and all funded projects that were not REU sites. I then split the data by year.

The first step in coding the REU awards data was to read each abstract and extract any statements about recruitment or selection, which are two different processes but were often conflated in the abstracts. Therefore, I included selection and recruitment statements and lumped them under the recruitment unless it was obvious that the statement pertained to selection. Third, I created a series of binary variables to document the student demographic characteristics (e.g.,
veteran, woman, underrepresented minority) mentioned in each recruitment and selection statement. This generated a spreadsheet populated by “1” for characteristic present and “0” for characteristic not present. For any single REU site, sometimes the recruitment and selection statements contained references to recruiting several demographic groups; all mentioned demographic groups received a “1” for present. An REU site abstract, then, could contain several demographic references.

The same approach for coding described above was used for identifying the most common recruitment proposals, which aimed at collecting and coding information about how REU sites proposed recruiting students not just naming who these students were (research question 4). The major difference between coding the recruitment strategies and learning about the demographic characteristics targeted for recruitment was in the analysis phase.

There were two principal kinds of calculations that I used to analyze the data and create the figures. The first calculation was for the recruitment proposals for specific demographic groups. For each year, I summed the mentions of each demographic group examined in this study. Then for each year, I summed all the sums of the specific demographic groups to create a grand total of the mentions of all targeted demographic groups for that year. This was the denominator out of which the percentages for the figures were calculated. For example, if a graph showed that women make up 11 percent of the recruitment statements for a year, that means that 11 percent of all demographic recruitment statements for that year proposed recruiting women. All charts that contain an X-axis that represented time were created in this way.

The second principal calculation was for the recruitment strategies. While the coding process was similar to how I conducted the demographic groups, the recruitment strategies had a
different denominator and were not included in the demographic recruitment analysis. For each year, I counted the number of recruitment strategies that an REU site proposed. I then summed these counts to calculate the total number of mentions of the recruitment strategies. For table 3, which is a frequency count of mentions of recruitment strategies across all eleven years included in this study, the denominator was the grand total of all recruitment strategy mentions across all eleven years. However, Figure 6, which has an X-axis representing time, was calculated using the procedure (not the same data) described in the previous paragraph. I reported out the findings in percentages because they control for the number of newly funded programs, which varied numerically by year. All tables and figures are accompanied by explanatory notes.

I conducted an interrater reliability study with one colleague. The data included sixty recruitment statements from sixty REU sites selected from 2017. Each of the two raters coded the recruitment statements independently. In aggregated we scored with 88 percent of agreement for all codes. When separating by sub-codes, the weakest agreement between my colleague and I was for recruitment strategies (50 percent), particularly when we had to identify organizations that specialized in broadening participation. I suspect this category is difficult for agreement because raters need to have narrow, background knowledge on certain programs to know if they specialize in broadening participation. In contrast, high interrater reliability is easier to obtain for demographic groups because their presence in the data requires little background knowledge or inference.

For most researchers, this 50% agreement may seem low. However, I want to point out that the function of calculating or paying attention to interrater agreement is to gain a sense of (a) how reproducible a study is and, (b) how much the findings should be trusted to be true. I’ve addressed (a) in the text and I address (b) here. When I conducted the coding process I carefully looked up every reference to an organization that I did not know about. This is how I learned about the various organizations that specialize in broadening participation in STEM, many of which were or are funded by the National Science Foundation. However, the additional coder that coded part of the data did not do this. Therefore, I argue that the data can be trusted much more than a 50 percent agreement would indicate. Note: I did not use the additional rater’s codes (or lack thereof) in the analysis, but only used mine.
3.3.3 Demographic variables.

Unfortunately, the demographic variables are difficult to define because of how the NSF collects the REU awards abstracts as well as inherent difficulties in studying racial, ethnic, and gender demographics. There were no official accompanying documents defining demographic terms used in the REU abstracts. I assumed a simplistic and intuitive matching of the student demographic characteristic and what that characteristic meant. For instance, when an REU site proposed recruiting Native American students I assumed that a Native America was a descendant of a tribe that claimed original human residency within the U.S. territory prior to, and continuing after, European contact. A U.S. veteran was taken to be a person who successfully participated one branch of the U.S. armed forces and was honorably discharged. The lack of strict definitions of sociodemographic groups opens the possibility that NSF and the REU proposers differ in how they define demographic groups for recruitment purposes.

The demographic group that did receive a further definition was “underrepresented minorities”. According to the CfPs, this category is composed of African Americans, Hispanics, American Indians, Alaska Natives, and Native Hawaiians or Other Pacific Islanders. In the REU CfPs, each of these sociodemographic groups (e.g., African Americans, Alaska Natives) did not receive further definition.

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12 For instance, is it best to use genetics or family history or just to let people self-describe their racial composition? Further, census demographic choices are fixed, even if the demographic options have changed over time, and it may be that many people do not self-identify with the existing demographic categories.

13 For a more serious demographic study, however, this kind of intuitive definition of sociodemographic groups would not suffice because putting individuals into proper group categories is a highly sensitive practice. The absence of definitions of sociodemographic groups in the REU Calls for Proposals could lead to confusion when REU sites do report on including demographic groups. For example, the category of Hispanics leaves open to interpretation if REU sites are supposed to look for Hispanic students who are U.S. residents, U.S.-born with foreign parents, half Hispanic and half some other racial group or if each of these “kinds” of Hispanics are equally targeted relative to the other.
3.4 Research Design and Analysis

I answered research question 1 by organizing a spreadsheet that noted when student demographic groups were recommended for recruitment and selection by the NSF. I answered research question 2 through the use of the previously described coding process for the REU awards abstracts. Employing frequency counts for demographic categories, I counted the mentions of proposed recruitment of specific demographic groups. For any year, I divided the specific references to demographic groups (e.g., women) by the total number of demographic references for recruitment for that year.

Research question 3, the historical analysis piece, required combining what I learned from research questions 1 and 2. The design was to note when certain sociodemographic groups were targeted for student recruitment in the REU CfPs and to examine if there were corresponding changes in the student recruitment plans proposed by the REU sites. I compared when new student groups were introduced in the CfPs (question 1) and checked the REU abstracts for student recruitment proposals (question 2). Careful inclusion of select years of the REU awards data was important because, to establish evidence of an association, I needed to check that these student demographic groups were not being recruited prior to their introduction in the CfPs. A slightly more intuitive way to think about the historical research design is a kind of correlation. A positive association was when student demographic groups were mentioned in the REU awards abstracts after the first year the demographic group was mentioned in the CfPs.
Table 2.2. Descriptive statistics for REU award sites and years included in this study, by year.

<table>
<thead>
<tr>
<th>Year of REU awards included</th>
<th>Newly funded REU sites</th>
<th>Number of Abstracts</th>
<th>Percent of missing abstracts</th>
<th>Abstracts with recruit/select statements</th>
<th>Percent of abstracts missing recruit/select</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>170</td>
<td>123</td>
<td>38%</td>
<td>26</td>
<td>79%</td>
</tr>
<tr>
<td>1990</td>
<td>152</td>
<td>148</td>
<td>3%</td>
<td>36</td>
<td>76%</td>
</tr>
<tr>
<td>1995</td>
<td>82</td>
<td>82</td>
<td>0%</td>
<td>42</td>
<td>49%</td>
</tr>
<tr>
<td>1999</td>
<td>125</td>
<td>121</td>
<td>3%</td>
<td>67</td>
<td>45%</td>
</tr>
<tr>
<td>2000</td>
<td>125</td>
<td>124</td>
<td>1%</td>
<td>67</td>
<td>46%</td>
</tr>
<tr>
<td>2001</td>
<td>144</td>
<td>144</td>
<td>0%</td>
<td>102</td>
<td>29%</td>
</tr>
<tr>
<td>2003</td>
<td>169</td>
<td>169</td>
<td>0%</td>
<td>124</td>
<td>27%</td>
</tr>
<tr>
<td>2006</td>
<td>172</td>
<td>172</td>
<td>0%</td>
<td>98</td>
<td>43%</td>
</tr>
<tr>
<td>2008</td>
<td>151</td>
<td>151</td>
<td>0%</td>
<td>99</td>
<td>34%</td>
</tr>
<tr>
<td>2014</td>
<td>187</td>
<td>187</td>
<td>0%</td>
<td>166</td>
<td>11%</td>
</tr>
<tr>
<td>2017</td>
<td>216</td>
<td>216</td>
<td>0%</td>
<td>165</td>
<td>24%</td>
</tr>
<tr>
<td>Mean</td>
<td>154</td>
<td>149</td>
<td>4%</td>
<td>90</td>
<td>41%</td>
</tr>
<tr>
<td>Stand Dev</td>
<td>36</td>
<td>37</td>
<td>11%</td>
<td>48</td>
<td>21%</td>
</tr>
<tr>
<td>Total</td>
<td>1506</td>
<td>1450</td>
<td>-</td>
<td>826</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2 displays some quantitative features of the REU awards abstract data for the years that I included in this study (36 percent of available data or 11 of 30 years). In the second column from the left are the number of newly funded REU sites for any fiscal year. While the average for the eleven years was 154 new REU sites per year, after a decrease in 1995, there was a general upward trend until 2017. This suggested a need to use percentages as an analytic unit to control for annual variability in the number of sites. The remaining columns (three through six) are rough measures of data quality. Column three describes the numbers of REU award abstracts as a portion of the total number of sites. The relevant inference from column 4 is that the 1987 publication of abstracts was missing over a third, but from 1990 until 2017 abstracts were reported with nearly every funded REU site. This meant that using this data source was more reliable after 1987. Column five and six display information about the inclusion of recruitment and selection statements in the abstracts. Examining column six shows that as the data
approached 2017 it was more common for the NSF to include recruitment and selection statements in the abstracts.

There are two important takeaways from Table 2. The first is that the quality of the REU abstract data for this study (i.e., inclusion of abstracts and recruitment statements) increased over time but was poor in the first few years (e.g. 1987 and 1990). Second, the average percent of abstracts contained (column six) and the variability represented in that column suggested that this data source will not produce a strong signal and probably not be representative of the recruitment plans contained in the full REU proposal. Thus, while this data source is useful because it includes information on many REU sites, the generalizability and the potentially low quality of the signal in the data are limitations to bear in mind.

4. Study Limitations

I want to remind the reader that the data will not support strong quantitative or strong generalizability claims. This study is highly exploratory in nature and the data give a “sense” of the complexity of student recruitment proposed by REU sites.

The most important limitation for this study stems from the nature of the REU awards data. Because the abstracts in the awards data are single or double paragraph length summaries of entire projects, the recruitment and selection plans are described superficially. Furthermore, there may be a social desirability effect infused into the abstracts. The abstracts are public-facing information about NSF projects and these abstracts are meant to be interpretable by lay persons and members of congress. It is possible that some recruitment strategies and sociodemographic groups are mentioned over others and that this is a systematic bias (i.e., chosen for a reason) and not a random bias. This limitation frames what can be said about the full spectrum of REU student recruitment proposals.
Lastly, I do not use inferential statistical methods. This study describes the data that I coded. I report out on the percentages and numbers as if they were accurate and reliable figures about student recruitment proposals, not estimates. This study is highly exploratory in nature and I intend to report out only on common trends in recruitment strategies proposed by REU sites. Because I could not establish standard error measurements around the recruitment proposals, the reader should not conclude that percentages and raw numbers that are near each other in quantity (two percent vs three percent) are true differences.

5. Findings

5.1 Student Recruitment Recommendations in the REU Calls for Proposals

Contained in the original REU Call for Proposals (CfPs) and the thirteen revisions (N=14) are recommendations for student selection and recruitment. The language of the CfPs moves between two kinds of broad categorizations for recruitment activities. One categorization is to target specific student groups (e.g., African American, Latino) and the second is targeting institutions where certain students are likely to be found (e.g., student at institutions with limited research programs). Both serve a similar end: certain kinds of students (e.g., Latinos) will likely be found at certain kinds of institutions (Hispanic serving institutions).

Some student demographic groups were consistently mentioned from 1987 and some were introduced periodically afterward (see Figure 1 below). From the first published CfP in 1987 through the latest revision in 2013, the NSF consistently recommended the recruitment and selection of the following student demographic groups: underrepresented minorities, women, persons with disabilities, students from outside of the REU host site, and students from institutions with limited research opportunities. Institutions that gained REU awards were under some level of obligation to look beyond their walls and recruit from other schools, region or
institutions. This focus on expanding research opportunities to individuals and institutions is consistent with the NSF’s Broadening Participation Framework (NSF, 2008).

While there were no deletions of targeted student demographic groups or institutions in later revisions of the CfPs, the REU CfPs did show the inclusion of additional sociodemographic groups for student recruitment. I observed four changes to the student recruitment recommendations. The first change was in the 1996 revision. The NSF stated that some of its directorates permitted the recruitment of K-12 teachers. Second, in the 2000 revision, the NSF urged the recruitment of students pursuing associates degrees. Third, in 2004, the NSF permitted the selection of students who had graduated from high school, enrolled in a postsecondary institution but had not yet begun their postsecondary studies. Finally, in 2009 the CfPs recommended the recruitment and selection of US veterans.

**Figure 2.1.** Demographic recommendations for selection and recruitment, by year of introduction into the REU Calls for Proposals.

In summary, my analysis of the REU CfPs revealed consistency and change over time. Some student sociodemographic groups have been historically recommended by the NSF and some have been introduced recently. In the next two sections I examine if the consistently
mentioned and newly introduced student sociodemographic groups also appeared in the REU awards abstract recruitment proposals.

5.2 Exploring Associations Between the CfPs and REU Awards Abstracts

The main thrust of the following section is to examine evidence of any association between when student groups are mentioned in the CfPs and if and when they are also proposed for recruitment by REU sites. To do so, I first report findings from the REU awards abstracts for the demographic groups consistently mentioned in the REU CfPs since 1987. Second, I show an analysis of when the newly introduced demographic groups in the CfPs also appeared in the REU awards abstracts.

5.2.1 Demographic groups represented continuously in the CfPs.

The CfPs consistently called for the recruitment and selection of URMs, women, persons with disabilities, students from institutions with limited research opportunities, and students from institutions outside of the host REU site. Figure 2 (below) is a display of the portion of all recruitment statements by year that contained reference to these groups. The denominator was the total number of recruitment references that mentioned demographic groups coded from the REU abstracts data for any single year.

With the exceptions of two demographic categories, the data demonstrated a high degree of stability over time. Underrepresented minorities, women, students with disabilities, and Native Americans have all hovered around stable averages since 1995 or so. Underrepresented minorities represented the most frequently proposed sociodemographic group for recruitment in this study, constituting roughly 27 percent of the student recruitment mentions in the REU award abstracts in any given year. Since about 2000, there appeared to be a gentle climb in the mentions of recruiting students from institutions with limited research opportunities. Opposingly,
since about 2001, the mentions of recruitment of students outside of the host site has been declining. There may be a conceptual overlap between these two categories where students from institutions with limited research opportunities are often found outside of the REU host site and therefore mentioning both in the limited REU abstracts is a waste of precious space.

The first exception to stability over time was the steep decline from 1987 to 1990 for the “outside of host site” student recruitment category. For the REU program, it is important to bear in mind that the period from 1987 to 1990 was special. First, 1987 was the first year of the REU program. Second, the REU program had a few changes that distinguished it from the previous undergraduate research program (Doyle, 1987; Fortenberry, 1990). The REU program’s recruitment focused shifted to targeting underrepresented minorities (URMs), women, and persons with disabilities, students from outside of the REU host institution, and expanding research opportunities to students who attended universities or colleges with limited research opportunities. A second important point is that 1990 marked the conclusion of an NSF survey evaluation study of the first three years of the REU program’s operations (Fortenberry, 1990). Changes to the 1990 CfP could have been informed by the evaluation findings. Third, there were changes in the CfPs language for recruiting students from outside of the REU host site. In the 1987 CfP, the expectation was that half of the students be from outside of the institution that received the REU grant while in 1990 the expectation was somewhat loosened to “a significant fraction” from outside of the host institution. I suspect the decline from 1987 to 1990 was potentially the result of three forces: (1) In 1987 it may have seemed novel to recruit students outside of the host site; (2) after 1990, the laxer language (from “half” to “a significant portion”) made it seem less interesting to report in the REU awards abstracts, and; (3) perhaps REU sites made less of an effort to recruit outside of their institution walls.
The second exception to stability was with the demographic category “women”. Since 1990, the portion of recruitment mentions for women in the abstracts appeared to be headed in a downward trend. This potential downward trend may signal a reduced interest in recruiting women because they have made significant gains in representation in certain STEM fields at the undergraduate level (e.g., psychology, biosciences) (NSF, 2017).

**Figure 2.2.** The portion of recruitment mentions in the REU award data abstracts by demographic group and year.

Note: Proportions are the number of mentions of a particular demographic over the entire number of recruitment statements for a given year. They do not sum to one hundred percent because there are other sociodemographic categories of students not included in this chart but, to avoid cluttered graphs, discussed elsewhere in this report.

Omitted from Figure 2 are a series of sociodemographic groups that were included in the REU CfPs from 1987 onward, including Native Pacific Islanders, Hawaiians, Latinos, Alaska Native, and African Americans. These groups were very poorly represented, typically occupying zero to two percent of the total recruitment statements for any year.
Figure 2 disaggregates the recruitment statements by specific demographic groups. However, these data can be aggregated into a single variable called total underrepresented minorities. This aggregated count consists of the following demographic categories: underrepresented minorities, women, persons with disabilities, Native Americans, African Americans, Latinos, Alaska natives, native Pacific Islander, and native Hawaiian. When examined this way (see Figure 3), the REU abstracts reveal that this category of underrepresented minorities accounted for, on average, 47 percent (SD=9 percent) of all demographic mentions across all years, with a low of 28 percent in 1987 and a high of 63 percent in 1990. This aggregated view of the data shows that, for any year included in this study, slightly less than half of the recruitment mentions correspond to underrepresented minorities groups.

Figure 2.3. Portion of recruitment mentions of “Total Underrepresented Minorities” variable.

In summary, the evidence is mixed and therefore inconclusive for the claim that the student groups consistently recommended for recruitment in the CfPs have also appeared in the REU awards abstracts. Some groups such as URMs, women, and students from institutions with limited research opportunities have almost always been proposed for recruitment. On the other
hand, some specific groups have shown very little or no representation (e.g., Asian Pacific Islanders, Alaska Native). What may be at the root of this low representation of specific demographic groups is that the broad category of underrepresented minorities (note: this is not the same as “total underrepresented minorities”) is being used as a catch-all for various demographic groups. Also, some of the less frequently mentioned groups may be mentioned for recruitment in the full proposals but not in the REU awards abstracts.

Two categories, limited research opportunities and students from outside of the REU host site showed an inverse relationship, suggesting a possible connection. In the CfPs, these two student groups are regularly mentioned in the same sentence or same paragraph. On the other hand, an aggregate analysis of the data reveal that nearly half of all the abstracts that contain recruitment proposals in any year mentioned recruiting from at least one demographic group considered to be underrepresented in STEM fields (see Figure 3) (NSF, 2017).

5.2.2 Associations for demographic groups newly introduced in the CfPs over time.

Just as there was a set of targeted student groups consistently mentioned in the REU CfPs, several new student demographic groups were introduced during certain years and continuously included afterward in the CfPs through the last revision in 2013. These were K-12 teachers (1996), students pursuing associates degrees (2000), students who graduated from high school who had enrolled in post-secondary education but had not yet started (2004), and students who are U.S. military veterans (2009). I investigated if adding these new student groups to the CfPs was associated with changes in the recruitment statements found in the REU award abstracts.

Figure 4 displays the results of the four key demographic groups as proportions of all recruitment statements for any single year included in this study. Two general remarks are warranted. First, all of the student demographic groups that were newly introduced into the CfPs
also appeared in at least one REU site recruitment proposals. Second, with the exception of community college students, no newly introduced student group constituted more than three percent of the total demographic recruitment proposals for any year.

5.2.2.1 K-12 teachers. K-12 teachers were introduced into the CfPs in 1996. From my reading of the abstracts, the goal of involving teachers in research experiences was to develop research-based teaching materials for educating K-12 students and to help teachers integrate aspects of the scientific method into their teaching. Prior to 1999, my analysis revealed no mention of recruitment proposals targeting teachers in the REU abstracts. In contrast, from 1999 onward there was at least one mention of recruiting K-12 teachers in the REU abstract awards data for each year included this study. It is worth noting that in 2003 that a separate research program was created for teachers, Research Experience for Teachers. Fluctuations in the rate of mention of recruiting teachers in the REU abstracts were so small that not much can be confidently said.

5.2.2.2 Community college students. The best represented student demographic group of the four analyzed here was “students pursuing associates degrees”, which I understand to be synonymous with community college students. While the inclusion of this demographic group began in the CfPs in the year 2000, there were numerous recruitment mentions in the awards abstracts prior to 2000. The years 1995 and 1999 both had five mentions of recruiting these students. After the year 2000 there was an observable increase in the recruitment statements targeting community colleges students through 2017, bearing in mind that this increase was only around two percent.

5.2.2.3 High school graduates. The recruitment of recent high school graduates was first included in the 2004 revision of the REU CfPs. An eligible high school student was defined as
one who graduated from high school, enrolled in post-secondary education, and had not yet began his or her studies there. After 2004, there was an increase from zero mentions of recruitment to two mentions in 2006 followed by a return to zero afterward. Given the preference that REU sites have had for selecting rising juniors and seniors (see Fortenberry, 1990), it may be that REU sites are reluctant to include students with little formal STEM education.

**Figure 2.4.** Portion of recruitment statements from sociodemographic groups introduced incrementally in the CfPs, by year.

![Graph showing proportions of recruitment statements from sociodemographic groups](image)

*Note: Vertical dashed lines and boxes represent the year the demographic group was introduced into the CfPs. Proportions are out of total recruitment statements mentioning any demographic information, for any given year.*

### 5.2.2.4 U.S. veterans

Lastly, U.S. veterans were introduced into the REU CfPs in 2009. Prior to 2009, there was no mention of recruiting veterans in the REU awards abstracts for years included in this study. However, in 2014 and 2017 the number of mentions in the REU awards abstracts was seven, accounting for around two percent of the total recruitment statements for either year.
In summary, the evidence is mixed for association between newly introduced student groups and their representation in the REU award abstracts. Community college students appeared in the REU abstracts prior to their mention in the CfPs. However, community college students are a difficult case because, as of 2012, “two-year students” are also mentioned as an example for students from “institutions with limited research opportunities” in the CfPs, which appeared earlier. For K-12 teachers, high school graduates, and U.S. veterans, Figure 4 provides evidence to suggest that following their introduction in the CfPs, some REU sites proposed recruiting them, but they represented a small fraction of total recruitment statements.

5.3 Student Groups Targeted for Recruitment but Not Mentioned in the CfPs

In this section, I introduce additional data from the REU awards abstract that support the claim that REU sites proposed recruiting students that are not mentioned in the CfPs. The intention of this section is to provide evidence that suggests that the CfPs are not the only influence on the student recruitment proposals for REU sites. As I show below, it may be the case that the NSF permits the recruitment of a wide assortment of students, some of whom fit more obviously into their Broadening Participation Framework and some that do not (NSF, 2008). For brevity, I included the following sociodemographic student groups in the subsequent analysis because they meet two criteria: 1) they were not specified in the CfPs and 2) they showed temporal patterning in the data. These four groups are first generation, low-income, students from non-PhD granting institution, and students who attend institutions that have a regional or university partnerships with the REU host site institution.

The results are displayed in Figure 5 below. With one clear exception, the majority of these student groups did not have a strong presence in the REU awards abstracts. Most groups averaged between one-half and four percent representation in any given year. The exception was
for recruitment proposals that targeted students who attended institutions with which the REU host site had a partnership. This student group had a peak recruitment proposal representation between the year 2000 and 2003 of about 14 percent of the total recruitment statements for those years. Note that this is a higher proportion than women but still considerably below the proportion of recruitment proposals for the “underrepresented minorities” category. After 2003, the proportion of recruitment statements targeting students within university partnerships declined precipitously. It is unclear why this occurred or if it is a true shift in student recruitment.

Two student categories deserve attention: first-generation college students and low-income students. These two groups are not large numerically nor as a portion of the total recruitment statements for any single year, occupying between zero and four percent of the total demographic recruitment statements for any year. Yet, it is noteworthy that REU sites have proposed targeting these groups since around 1999, with mentions of recruiting low-income students starting as early as 1995. These are students groups whose demographic representation is not tracked by the NSF nor are they mentioned in the REU CfPs (NSF, 2017). Yet, it may be that some REU sites identified these groups as underrepresented in STEM fields (see Chen, 2013; Verdín & Godwin, 2015).
These examples of sociodemographic groups, ones that were not in the CfPs but that have been a small fraction of REU recruitment plans for decades, complement the prior section where I examined the association between student groups mentioned in the CfPs and recruitment statements in the REU abstract data. Looking across these data, I conclude that sociodemographic groups not mentioned in the CfPs were at least as often proposed, if not more commonly proposed, for recruitment compared to some student groups that were introduced into the CfPs. For example, K-12 teachers and high school graduates both had roughly one percent of the total recruitment statements averaged across all years included in this study. Similarly, first generation and low-income students occupied about one percent of total recruitment statements averages across all years included in this study. Looking at institutions for recruitment, community colleges represented an average of four percent of the total recruitment statements averages across all years. Yet, regional institutional collaborations, which were not mentioned in
the CfPs, represented an average of 10 percent of all recruitment statements across all years. On the other hand, it could be that some of these institutional partnerships are between research institutions and community colleges, but without a closer examination of a different kind of data source it is difficult to know.

These patterns have one potential implication related to research on REU recruitment strategies. The inclusion of new student demographic groups in the REU CfPs does not appear to equate to these same groups being targeted for recruitment by REU sites as far as the abstracts provide a glimpse into actual recruitment intentions. Some sociodemographic groups showed very weak signs of proposed recruitment, such as high school graduates, despite being listed in the CfPs. Other groups, such as first-generation and low-income students, appeared in the REU data set without being mentioned in the CfPs. Due to the nature of this study, it is impossible to say what caused this pattern.

6. Commonly Proposed Student Recruitment Strategies

In this section, I report on the student recruitment strategies that REU sites proposed in the awards abstracts that summarized their successful grant proposals to NSF. The discussion shifts from who REU sites proposed recruiting to how they proposed to recruit. The only data source used in this section was the REU awards abstracts. The denominator reported in Figure 6 below was the total number of recruitment strategies proposed in any year, not the total number of demographic recruitment statements as has been the case of the preceding analyses. The average number of unique recruitment strategies proposed for any year included in this study was five per year. By “unique recruitment strategies” I count a single, unique strategy regardless of however many times it was mentioned by other REU sites. For example, if in the year 1999 the only recruitment strategy proposed was to use professional conferences to recruit students and it
was mentioned by twenty-seven distinct REU sites, I would count this as one unique recruitment strategy.

I recorded a total of eight unique recruitment strategies that were proposed at least once during the eleven years of REU awards analyzed in this study. I organized these practices into two kinds: actions intended to recruit students and locations where certain students might be found. The action strategies were: using university partnership and relationships, broadening participation organizations, university diversity programs, traditional methods (flyers, websites, mailings), personal and professional contacts, campus visits. The locations for targeted recruitment were: minority serving institutions and professional conferences (see Table 3).

Minority serving institutions and pre-existing university partnerships accounted for 70 percent of the recruitment strategies proposed across all REU award years included in this study. The following six recruitment strategies comprised the other 30 percent. Although it is difficult to know what caused such a lopsided distribution in favor of minority serving institutions and university partnerships and relationships, one reasonable explanation is that the REU program sites aimed to target diverse undergraduate students and therefore used minority-serving universities as recruitment centers. Rather than proposing new relationships with universities, one efficient method is to use pre-existing university relationships. University diversity programs (listed fourth in Table 3) appears to be a promising avenue for recruiting students from underrepresented groups within the host institution.
**Table 2.3.** Frequency count for proposed recruitment strategies aggregated across all study years.

<table>
<thead>
<tr>
<th>Recruitment Strategy</th>
<th>Count</th>
<th>Portion of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minority serving institutions</td>
<td>138</td>
<td>40%</td>
</tr>
<tr>
<td>University partnerships and relationships</td>
<td>93</td>
<td>27%</td>
</tr>
<tr>
<td>Broadening participation organizations</td>
<td>34</td>
<td>10%</td>
</tr>
<tr>
<td>Traditional methods (flyers, website, mailings)</td>
<td>24</td>
<td>7%</td>
</tr>
<tr>
<td>University Diversity Programs</td>
<td>22</td>
<td>6%</td>
</tr>
<tr>
<td>Personal and professional contacts</td>
<td>22</td>
<td>6%</td>
</tr>
<tr>
<td>Campus visits</td>
<td>9</td>
<td>3%</td>
</tr>
<tr>
<td>Professional Conferences</td>
<td>6</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>348</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Note: This table contains a frequency count of the number of mentions of unique recruitment strategies across all eleven years included in this study.

From Figure 6 (below) it is possible to learn which of the recruitment strategies was the most commonly proposed for any given year in the REU abstract awards. For most years, the three most commonly proposed recruitment strategies were recruiting from minority serving institutions, using university partnerships and relationships, and using professional organizations that specialized in broadening participation efforts. Indeed, this ordering held up when I conducted a frequency count of all recruitment strategies across all years (see Table 3 above). It is also clear from Figure 6 that REU sites have been proposing a variety of recruitment strategies since 1987.
Figure 2.6. Proportion of recruitment strategies proposed for each year in the REU award data.

Note: Proportions are out of total recruitment strategies mentioned from a given year, including multiple mentions per REU site award. This is not the same as the recruitment statements, which are references to targeted student demographic characteristics.

7. Discussion

The central objective in this article was to contribute to the scholarly and practical knowledge on recruitment practices for programs that seek to broaden undergraduate participation in the sciences. Despite the significance of undergraduate research programs for retaining underrepresented students in the STEM pipeline (Laursen et al., 2010; Lopatto 2007; Nagda et al., 1998), recruitment practices of undergraduate research programs in general, and the REU program in particular, have a thin research base. This is unfortunate because vigorous and strategic recruitment may be one of the few mechanisms by which students of underrepresented groups can learn about NSF programs and, thus, have a chance to participate in undergraduate
research programs. The REU program is an interesting case study in broadening participation for two reasons. First, one of its missions is to reduce demographic underrepresentation in STEM fields. Second, it would accomplish this goal through recruiting and then selecting students into REU sites. Every year, REU sites must recruit and select students.

The researchers and evaluators cited in the literature review identified some recruitment strategies used by REU sites that included relying on colleagues at other institutions, traditional recruitment methods such as posting announcements at postsecondary institutions, campus visits, campus recruitment offices, the use of conferences as recruitment locations, direct mailings to institutions, and using the NSF’s REU website resources. This study adds to this list of student recruitment practices: recruitment from minority serving institutes, leveraging university partnerships and relationships, reaching out to broadening participation organizations, and using university diversity offices, most likely, for recruitment from the REU host institution. Combined, these two lists offer a sizable collection of recruitment practices that can be used by new and old REU sites to recruit undergraduate students from the general population and students from underrepresented groups in the sciences.

Laursen et al. (2010) made a distinction between formal and informal recruitment practices, where formal recruitment practices were described as attempts by science departments to generate widespread awareness of the undergraduate research opportunities. The practices identified in this study likely correspond to the formal recruitment practices identified by Laursen and colleagues. Future studies should consider examining if informal recruitment systems operate in REU programs, given that the recruitment for REU program is different from the liberal arts colleges that she and colleagues studied. For one, the REU program recruits
nationally and has limitations on how many students can participate from the REU host institution.

Findings from the REU awards abstract data show that, at least at the proposal stage, the REU awardees have been attuned to the REU’s broadening participation mission. Figure 3 showed that over half of the recruitment mentions of student groups for any year were from the underrepresented student groups consistently mentioned in the CfPs. The REU program has consistently recommended the recruitment of students from select underrepresented groups in its calls for proposals (CfPs). These groups included underrepresented minorities, women, persons with disabilities, students from outside of the REU host site, and students from institutions with limited research opportunities.

Some sociodemographic groups were never or rarely mentioned in the REU awards data despite their mention in every REU CfPs. For example, African Americans, Latinos, Alaska Natives, Hawaiian Natives, Pacific Islanders, and Native Americans were not frequently mentioned for recruitment across all years of the REU awards abstract included in this study. For advocates of broadening participation, this finding would be concerning if it generalized to the full recruitment proposals because it would mean that some underrepresented groups are being ignored. A future study could look more closely at how active REU sites are in reaching out to these groups.

The periodic inclusion of new student demographic groups into the CfPs did not mean that REU sites proposed recruiting them, as per the REU award abstract data. The demographic groups that most strongly supported the association were K-12 teachers and U.S. veterans because these groups showed up in the REU recruitment plans only after their inclusion in the CfPs and continued to be represented in subsequent years. REU sites also have proposed
recruiting from student groups that were never mentioned in the CfPs, such as first-generation college students and low-income students. Furthermore, recruitment interest in student groups and institutions not mentioned in the CfPs has been substantial and stable over time. It may be that the NSF permits the recruitment of students from groups other than those that it formally recognizes as underrepresented in the sciences. Future studies can examine the NSF’s position on the recruitment of students who are not mentioned in the CfPs.

Overall, the findings from this study support the claim that the REU program has been heeding its mission to reduce underrepresentation in the sciences. My analysis showed that REU sites intend to recruit from underrepresented groups and have identified a set of practices to do so. There is some cause for concern that certain student groups are being overlooked in recruitment, but additional studies are required to substantiate that claim. For the moment, the REU sites have proposed recruiting from a wide diversity of student demographic groups.

8. Future Studies

First, for the sake of accountability, it would be productive for the NSF to investigate if REU programs are in fact successfully recruiting from the proposed student demographic groups. The concern is that REU sites are receiving REU funds partly based on their recruitment plans but in practice are not executing them well.

Second, it would be valuable to learn which practices are effective for recruiting a diverse applicant pool. Similarly, it will be informative to learn what successes and frustrations REU practitioners encounter when implementing their recruitment plans.

Third, it is unlikely that all recruitment strategies equally work well for all underrepresented groups. There will likely be a need for a more comprehensive and nuanced set
of recruitment strategies that examine which places, institutions, and recruitment strategies align best for recruiting from specific underrepresented groups.

Fourth, complementary to recruiting a diverse group of individuals into REU programs is the student selection process. Studies should look into the diversity of REU selection processes, selection committees operationalize their selection criteria, and how these processes play out in selecting (or not) diverse students. I explore this question more directly in article 3.

Fifth, using Laursen et al.’s (2010) finding that some university departments engaged in informal recruitment practices, it may prove fruitful and important to understand if REU sites also use informal recruitment and selection practices. Perhaps it is the case that informal recruitment and selection practices are reserved for student candidates that attend the REU host institutions and formal recruitment and selection are applied to external student candidates.

Sixth, as shown in table 2.3, the second most common method for student recruitment was partnership between different universities. This is a potentially highly valuable and powerful recruitment tool as high research output universities can partner with community colleges and smaller universities to recruit students for REU experiences. However, the data here do not permit a close look at the types of collaborations, the nature of the universities connections, and if they are in fact productive for recruitment. Future studies would do well to unpack this recruitment method to learn more about its practice and utility.

In closing, I want to share an observation that did not show up strongly in the data but, for that reason, ought not be overlooked. It may be the case that one fruitful way for the NSF to increase recruitment of specific underrepresented student groups is through project-demographic alignment. I define project-demographic alignment as there being a significant relationship between the REU research project and a specific demographic group. After reading over one
thousand abstracts, I often noticed that the REU recruitment goals appeared to have nothing to do with the REU projects. That is, the intellectual merit and the broader impacts appeared disconnected. However, some REU projects appeared to align their projects with the demographic group that they proposed recruiting.

If it is important to recruit students from certain underrepresented groups, it may be useful for NSF grant reviewers to encourage and select projects that are consciously aligning research projects with the target demographic group. I want to report on two interesting project-recruitment aligned REU sites. REU award #1659795’s intellectual merit pertained to national cybersecurity and this site sought to recruit U.S. veteran students. REU award #1659225 proposed a community educational outreach activity to a deaf and hard of hearing community and also sought to recruit students who had this specific kind of disability.

There are two reasons why this project-recruitment alignment might be beneficial for the REU sites in terms of research production. First, these students’ life experiences might form useful knowledge bases and launching points for contributing to research. Second, these students might be inherently more invested in the research compared to other students who do not have their life experiences.
Appendix A.

**Table 2.4.** National Science Foundation (NSF) document numbers for the fourteen Calls for Proposals used in this study.

<table>
<thead>
<tr>
<th>CFP Document Year</th>
<th>NSF Document Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>Cannot locate on document</td>
</tr>
<tr>
<td>1990</td>
<td>NSF 92-92</td>
</tr>
<tr>
<td>1993</td>
<td>NSF 93-112</td>
</tr>
<tr>
<td>1996</td>
<td>NSF 96-102</td>
</tr>
<tr>
<td>2000</td>
<td>NSF 00-107</td>
</tr>
<tr>
<td>2001</td>
<td>NSF 01-121</td>
</tr>
<tr>
<td>2002</td>
<td>NSF 02-136</td>
</tr>
<tr>
<td>2003</td>
<td>NSF 03-577</td>
</tr>
<tr>
<td>2004</td>
<td>NSF 04-584</td>
</tr>
<tr>
<td>2005</td>
<td>NSF 05-592</td>
</tr>
<tr>
<td>2007</td>
<td>NSF 07-569</td>
</tr>
<tr>
<td>2009</td>
<td>NSF 09-598</td>
</tr>
<tr>
<td>2012</td>
<td>NSF 12-569</td>
</tr>
<tr>
<td>2013</td>
<td>NSF 13-542</td>
</tr>
</tbody>
</table>
Appendix B.

Understanding NSF directorate subcultures through differences in proposed recruitment practices for REU sites funded by different NSF directorates.

Following the dissertation defense, some committee members felt strongly that one of the most interesting empirical findings from this study was the taxonomy of recruitment practices displayed in Table 2.3. Consequently, they asked for a deeper analysis of those recruitment strategies through a bivariate analysis where the recruitment strategy taxonomy was reanalyzed by NSF directorate. Below, I produce a cross tab and two graphs that further deepen the analysis that began with Table 2.3.

The hypothesis that the committee members offered was that different NSF directorates have distinct cultures and that these cultures might manifest through different patterns of proposed student recruitment strategies. In other words, it may be the case that the biosciences directorate, for example, tends to fund REU sites that recruit most commonly from minority serving institutes than, say, from campus visits. The Math and Physical Science directorate may have a different pattern. Comparing quantitative findings might elucidate patterns of thought or practice that are culturally specific to NSF directorates.

Because the committee did not specify a theory of culture that would assist with analysis and since this dissertation does not deal with culture much, I want to offer a thin theory of culture that will help with the analysis of the data. I do this at the risk of stepping into a realm of social theory that I know very little about. I understand culture to be a latent construct that is self-sustaining but also changing over time. It is latent in the sense that no one can observe a thing called “culture” in any environment but we can infer that differences in culture exist by observing behavior and talk of different groups of people (Schein, 2010). These differences will
be roughly contained to groups of people and will be less common in other groups. In the case for this study, differences in NSF directorate cultures are hypothesized to manifest through one indicator: differences in proposed recruitment strategies.

The statistical technique employed in this section is descriptive and not inferential, just like the rest of the study. Therefore, there is no statistical test that will help distinguish between the number of proposed strategies in one directorate versus another. The difference “test” will have to be visual and intuitive and somewhat tentative. This data collected in this study are not of such high quality that differences can be determined with great confidence (see “limitations” section above).

Findings

The findings are split into two kinds. First, this analysis is concerned with how the proposed student recruitment practices are split across the NSF directorates. For this analysis, I lead with the recruitment strategies and split them by the directorates. Second, the main analysis, however, is concerned with signs of difference across directorates. Therefore, I will examine the internal composition of directorates by the recruitment practices. That is, I will look at the proposed recruitment practices for each directorate and then compare these compositions across each other.

**Descriptive Statistics of Student Recruitment Proposals by NSF directorates.**

In this section, I show some descriptive statistics for the data used to construct the two following graphics that comprise the bulk of this appendix study.
Table 2.5. Descriptive statistics for student recruitment proposals by NSF directorate, raw numbers.

<table>
<thead>
<tr>
<th>Proposed Recruitment Strategy</th>
<th>MPS</th>
<th>BIO</th>
<th>ENG</th>
<th>CISE</th>
<th>GEO</th>
<th>SBE</th>
<th>EHR</th>
<th>OD</th>
<th>Total per recruit strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minority Serving Institute</td>
<td>62</td>
<td>26</td>
<td>29</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>138</td>
</tr>
<tr>
<td>University Partnership</td>
<td>40</td>
<td>13</td>
<td>18</td>
<td>12</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>BP Participation Organization</td>
<td>17</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>34</td>
</tr>
<tr>
<td>Traditional</td>
<td>6</td>
<td>12</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>University Diversity Program</td>
<td>6</td>
<td>3</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Personal/Professional Contacts</td>
<td>9</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Campus Visits</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Professional Conferences</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Total per directorate</td>
<td>145</td>
<td>71</td>
<td>68</td>
<td>27</td>
<td>22</td>
<td>12</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Total abstracts with recruit</td>
<td>80</td>
<td>50</td>
<td>47</td>
<td>22</td>
<td>16</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: the first figure below is a graphical representation of the rows in this chart while the second figure is a representation of the columns.

From the table above, one can observe that the Math and Physical Science (MPS) directorate is has the strongest representation in terms of recruitment proposals, followed by Biosciences (BIO) and Engineering (ENG). This is significant because if it is indeed true that subcultures influence how recruitment proposals are formulated, accepted, and then funded, then these three directorates will have an usually large pull on what any aggregate description of recruitment proposals looks like. The MPS directorate also funded the most REU sites in this sample, at 604 REU sites. The next closest was the Biosciences directorate with 392 REU sites. It appears that a major funding priority of the NSF is in mathematics and physics.

Another important note from this descriptive table is the weak representation of the three right-most NSF directorates: Social, Behavioral, and Economic sciences (SBE), Education and Human Resources (EHR), and the Office of the Director (OD). Because these three offer little to the analysis, I omit them from the following graphs to conserve space and increase an ability to visually compare the NSF directorates of the most impact. For the following graphs, I exclude these three directorates from the calculations also.
Analysis of recruitment strategy by NSF directorate.

Figure 2.7. Representation of the portion of student recruitment strategies proposed by NSF directorates.

Note: The denominator is “total per recruit strategy” as found in the Table 2.5 above.

As one would expect based on the descriptive statistics, the Math and Physics Science directorate dominates the graphics (MPS, in light blue). Its representation is strong across all the strategies. The Biosciences directorate also has strong representation in all fields, while Engineering has less widespread representation.

Searching for distinctions in directorate culture requires examining for differences in representation. From the figure above, one can note that MPS tends to propose the use of professional conferences, university partnerships, and minority serving institutions more than other directorates. On the other hand, the Bioscience directorate REU sites tended to propose campus visits and traditional avenues of recruitment (mailings) more than other directorates. Engineering seems particular in its proposals for using university diversity programs and its total absence of campus visit proposals.
Analysis of NSF directorate by recruitment strategy.

Figure 2.8. Stacked bar analysis of the internal composition of NSF directorates, by proposed student recruitment strategies.

Note: The denominator is “total per directorate” as shown in Table 2.5

The main difference between the previous figure and this one is that this figure specifically highlights the internal composition of the NSF directorates. It allows for an easier and clearer comparison across the directorates. By using percentages, the data in this figure roughly control for the fact that there is a large range of samples sizes across the directorates, with MPS (n=80) being the most represented and CISE being on the lower end (n=22). However, the large disparity between the most represented (MPS) and least represented (GEO) directorates should kept in mind as it comes to roughly a fivefold difference.

One of the strongest similarity across the directorates is that they all seem to use minority institutions about the same for student recruitment groups. If this pattern holds to actual
recruitment practices for all directorates, then using minority serving institutions as a recruitment strategy is well positioned for research endeavors. Indeed, research on minority serving institutions would be of interest to all directorate program officers and numerous REU sites would have experience with this kind of recruitment. The same observation roughly holds for university partnerships, but Computer & Information Science and Engineering (CISE) appears to use these partnerships a higher proportion of their total recruitment practices (but not in terms of pure numerical quantity, as the MPS directorate would be first).

In terms of differences that could highlight cultural distinction across directorates, there are almost none that are noteworthy in this analysis. Any significant difference can almost surely be explained away as a sampling artifact. For instance, CISE does not report using traditional means (flyers, emails, mailings) as a recruitment tool. However, because their sample size is so small (n=22), it seems risky to suggest that this is a true quantitative finding. On the other hand, it does appear that engineering proposes using almost no professional and personal contacts for recruitment. Future research might look more closely at this to see if it is true that engineering REUs tend not to use professional and personal contacts for recruitment, surely a peculiar finding it was true.

Conclusion

There is one strong conclusion from this data: a better analysis would follow from more quality and equally distributed data. In an ideal experimental situation, each NSF directorate would have roughly the same amount of baseline data and could thus be compared more fairly. However, the NSF does not fund each directorate equally and therefore the data are not equally distributed across all directorates. This complicates the analysis because the few examples of
REU sites from some directorates compared to others exacerbates the sampling problem; the error terms would be very large around some of the directorates.

With that limitation in place, there are some possibly true similarities and noteworthy differences across the NSF directorates. This is the extent to which I am able to support common and different patterns of activity across directorates.

Similarities:

- All NSF directorates represented in the two previous charts tended to propose recruiting from minority institutions, constituting between six and 46 percent of recruitment statements (see Figure 2.7). This is a common experience to all directorates and many REU sites.
- Using university partnerships is also a commonly proposed recruitment strategy.

Differences:

- Compared to other directorates, Biosciences tends to infrequently propose using organizations that specialize in broadening participation efforts.
- Compared to other directorates, Computer and Information Science and Engineering directorate tends to not use traditional methods of recruitment (phone calls, emails, mailings).
- Compared to other directorates, Engineering tends to not use personal and professional networks for recruitment.
Appendix C.

A more fine-grained Exploration of REU Recruitment Strategies

In this final appendix, I conducted an analysis of the REU recruitment practices summarized in Table 2.3. Dissertation committee members urged that the recruitment strategies in Table 2.3 should be supplemented by whatever additional evidence might be found in the REU abstract data. This appendix is a response to that request.

The data used for this analysis were taken from the previous study, and my description in the methodology section still holds for how this data was collected and analyzed. However, I only used a subset of the REU abstract data. I organized the data set so that only REU abstracts that were coded for recruitment strategies were included. Second, I opted to select as many REU recruitment statements (a selection of the REU abstract data) that mentioned only one recruitment strategy. Some REU abstracts mentioned several recruitment strategies. Because some recruitment categories were not well represented (e.g., professional conferences had only six mentions for the entire data set), I did use some REU site data that proposed more than one recruitment strategy. Table 2.6 below displays the number of examples that I analyzed per each recruitment strategy. To be clear, an “example” is the segment of the REU abstract that contains information about that REU site’s recruitment strategy.
Table 2.6. Sample sizes of examples used in the recruitment strategy analysis.

<table>
<thead>
<tr>
<th>Recruitment Strategy</th>
<th>Number of examples analyzed</th>
<th>Portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minority serving institutions</td>
<td>70</td>
<td>34%</td>
</tr>
<tr>
<td>University partnerships and relationships</td>
<td>62</td>
<td>30%</td>
</tr>
<tr>
<td>University Diversity Programs</td>
<td>22</td>
<td>11%</td>
</tr>
<tr>
<td>Personal and professional contacts</td>
<td>22</td>
<td>11%</td>
</tr>
<tr>
<td>Broadening participation organizations</td>
<td>13</td>
<td>6%</td>
</tr>
<tr>
<td>Traditional methods (flyers, website, mailings)</td>
<td>8</td>
<td>4%</td>
</tr>
<tr>
<td>Campus visits</td>
<td>5</td>
<td>2%</td>
</tr>
<tr>
<td>Professional Conferences</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>205</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The analysis phase of this data was to read through each abstract once or twice and write a short summary. These summaries were then clumped into themes to facilitate the analysis. Some recruitment strategies had more text and interesting commentary while some were relatively bereft of useful information. In what follows, I summarize my findings by recruitment strategy.

The quality of the data varied. Some REU site recruitment statements specifically mentioned universities or colleges by name while other REU recruitment statements were vague (e.g., recruitment from institutions with high minority enrollment).

**Minority Serving Institutes**

With 138 mentions in the REU abstracts analyzed in this study, recruitment from minority serving institutes was the most commonly proposed recruitment strategy that I found. Because the REU abstract awards did not come with a definition of a minority serving institution, I opted for the federal government’s definition. Typically, a minority-serving institution has a set of enrollment criteria describing its student body. They are institution of higher education, enrolling undergraduates and above. Below is a list of categories of federally recognized minority-serving institutions:
• Historically black colleges and universities (HBCU) – founded prior to the Civil Rights Act of 1964. Created primarily for the education of African Americans.

• Black-serving non-HBCUs – While not technically an HBCU, in these universities and colleges African-Americans constitute at least 25% of total undergraduate enrollment while other minority groups make up less than 25% of total undergraduate enrollment.

• Hispanic-serving institutions - In these universities and colleges Hispanics constitute at least 25% of total undergraduate enrollment while other minority groups make up less than 25% of total undergraduate enrollment.

• Asian Pacific Islander-serving institutions - In these universities and colleges Asian Pacific Islanders and Asian Americans constitute at least 25% of total undergraduate enrollment while other minority groups make up less than 25% of total undergraduate enrollment.

• American Indian-serving institutions - In these universities and colleges American Indians constitute at least 25% of total undergraduate enrollment while other minority groups make up less than 25% of total undergraduate enrollment.

• Other minority-serving – intuitions in which minority students are at least 50% of the total enrollment but do not fit into any of the above categories.

I reviewed 70 examples of REU sites that proposed using some kind of minority-serving institution as a recruitment site. The most frequently proposed minority-serving institution was the HBCU, but women’s colleges, Hispanic-serving institutions, and tribal colleges were also mentioned. The majority of examples read as if the REU host site was going to look beyond its boundaries for students from underrepresented groups but some noted that the host institution
was a minority-serving institutions. These institutions proposed recruiting from within their own student body. Although not every common, some REU sites mentioned women’s colleges or tribal colleges or HBCUs by name.

**University Partnerships and Relationships**

With 93 mentions in table 2.3, the use of university partnerships and relationships was the second most commonly proposed recruitment practice by the REU sites examined in this study. I identified sites using partnerships, collaborations, and existing relationships whenever they mentioned recruitment through “partnerships”, “collaborations”, “agreements”, or “relationships.” I understand these terms to be roughly synonymous, although a more careful study of these recruitment strategies may reveal that the terms pick out different kinds or levels of networking among institutions. This category is similar but still distinct from the use of “personal and professional contacts.” In the case of university partnerships, the salient feature is the institutional bridge or bond, not the fact that individuals or faculty have developed individual level relationships with each other for student recruitment. Partnerships with other institutions or being a member of a professional network or research consortia may open productive avenues for student recruitment.

The kinds of partnerships and relationships mentioned by REU sites varied immensely. Below I offer a list of the major types of relationships that I observed in the data:

- **Regional relationships** – some universities and colleges have relationships or partnerships that spanned geographic regions. For instance, one REU site spoke about recruiting from the Triangle Universities, a collection of three institutions in North Carolina. Student recruitment was proposed to be carried out in these three institutions.
- State university systems – Some REU sites leveraged their position within state university systems for recruitment. One university, perhaps the strongest research institution in the state, might gain an REU site award. Recruitment would be proposed to span outward into the state system, thereby recruiting from schools with weaker research infrastructure.

- Existing Relationships or Agreements with nearby colleges – Other REU sites leveraged pre-existing agreements with other colleges and universities. The REU abstracts very rarely shed light on what these agreements or relationships were. However, for the most part the agreements appeared to facilitate recruitment from certain institutions. For instance, one REU site noted that it will recruit from relationship at “five partner institutions.” Another REU site wrote about existing agreements with a set of tribal colleges located nearby. One potentially powerful example of existing relationships is when an REU host site develops a relationship with a strong state community college system, such as in the state of California.

- Research collaborations – another type of relationship mentioned by REU sites was research collaborations. Although little can be found in the REU abstract to discuss what these are, presumably they are university or institutional relationships founded on research interests or shared grants across institutions. Note that not all REU awards go to universities; some go to research museums like the Smithsonian or to government laboratories that do not have captive student bodies. The promise of this recruitment avenue is that stronger ties are created between institutions where faculty and researchers work together often. Increased communication may facilitate student recruitment.
- Consortia – Although not mentioned frequently, consortia were another type of institutional partnership that might facilitate proposed student recruitment. Consortia appeared to be like professional or research interest national organizations that institutions and individual can belong to. These networks, and their formal newsletters or listservs, could be used to enhance recruitment. Two examples were the New York City Archaeological Consortium and the National Astronomy Consortium.

**University Diversity Programs**

Table 2.3 listed university diversity programs as the fifth or sixth most common recruitment strategy. Some large universities have departments or offices dedicated to serving and cultivating a diverse student body. These departments vary in their charges, but they appear to be potentially productive sites for student recruitment in at least two senses. First, because REU host sites are allowed to recruit a significant number of students from within their host institutions, diversity offices can be internal recruitment sites for students from underrepresented groups. Second, noting how diversity offices are useful for internal recruitment, REU sites can reach out to diversity offices in other institutions to engage in external recruitment. I reviewed 22 examples of use of diversity offices for student recruitment.

University diversity programs themselves are quite diverse. Some are general to the student body (e.g., retention of first generation students) and others are specific to departments or disciplines (e.g., engineering). Occasionally, national diversity programs can be located inside of a university, a stroke of luck for REU sites looking for easy recruitment pathways. Other times, national programs, like the McNair scholars program, may have a program inside of a university, which also may assist with internal recruitment.
Personal and Professional Contacts

In table 2.3., personal and professional contacts were tied with university diversity programs for the number of mentions. I noted early that personal and professional contacts were similar to institutional partnerships except that they were characterized primarily by interpersonal relationships, that is, person to person. Being person to person, these contacts can occur inside of institution (e.g., faculty recommending students) or across institutions. Like diversity programs, these contacts can be leveraged for internal or external student recruitment.

Because of the limited examples (n=22) and the diversity of the examples, it was difficult to create themes. Some REU sites proposed using contacts at specific universities while other REU recruitment abstracts discussed professional contacts vaguely (e.g., using a program director’s contacts). One REU site proposed using faculty at other institutions to identify “promising, motivated” students, a networking case that was similar in tone to Laursen et al.’s (2010) notion of informal recruitment. One interesting case was Northern Illinois University which recruited faculty and student pairs at HBCUs for engagement in research. Sometimes, university alumni were contacted to expand social networks for student recruitment.

Broadening Participation Organizations

Table 2.3., located organizations that specialized in broadening participation as the third most commonly proposed recruitment strategy. These organizations have missions that support the broadening participation of underrepresented groups in sciences. These missions may be the heart and soul of the organization or only part of the organization is dedicated to broadening participation. Many of the mentioned organizations were initially funded by the National Science Foundation or continue to be funded by the NSF. Because their mission and activities overlap
nicely with the diversity emphasis in REU student recruitment, it is somewhat surprising that these organizations were not mentioned more frequently in the REU recruitment proposals.

Some REU sites were specific in mentioning the names of organizations and other abstracts spoke vaguely of “agencies” involved in broadening participation. I reproduce a list of organizations cited by name in the REU abstracts:

- The National Consortium for Graduate Degrees for Minorities.
- Louis Stokes Alliance for Minority Participation in Science (LSAMP), both national and regional groups.
- College Assistance Migrant Program
- Students and Technology in Academia, Research, and Service (STARS)
- Keck Geology Consortium
- Various minority and women engineering organizations

The REU abstract awards data are thin on exactly how these organizations are used for recruitment. However, one can imagine that an REU host site contacts them for access to their listserv or newsletter publications for student recruitment. It is also possible that some REU sites form tight relationships with a few of these organizations to increase student recruitment.

**Traditional Methods**

In table 2.3., traditional methods of recruitment had 24 distinct mentions in the REU abstracts data and were the fourth most common recruitment methods. Traditional methods include at least using flyers, posters, classroom announcements, direct mailings, the general NSF REU website, and specific websites designed for the REU host site. Recall that the REU program began in 1987 and some of the data I analyzed was from 1987 and early 1990s when the internet and email were still in development. Some of these earlier REU sites would have used older
forms of communication, such as sending letters and making phone calls to contacts and other institutions targeted for recruitment. My analysis of traditional methods of recruitment add almost nothing interesting or new to the literature body. Perhaps of interest to researchers is the use of promotional videos sometimes produced by REU sites to recruit students. These videos might be examined for content or usefulness. Some REU sites propose targeting specific institutions, such as women’s colleges and HBCUs, with mailings to faculty there.

Campus Visits

With only 9 mentions in table 2.3., campus visits are not frequently proposed by REU sites. Perhaps it is because these methods are cost and time intensive and require advanced scheduling. I examined five cases of campus visit proposals. A few REU sites proposed visiting targeted universities, such as those with limited research capacity and institutions with high minority enrollment. The principal investigator from one REU site proposed visiting students and conducting interviews at an institution.

Although perhaps uncommon, visiting campus may be useful for REU sites. They may be useful for establishing relationships with staff and doing something like a day of interviews with a set of students who had been recruited by faculty for this purpose. Campus visits may be important, also, for recruiting certain kinds of students, especially if the visit is accompanied by a presentation about the REU site and what it can offer for the student.

Professional Conferences

The least common recruitment proposal was for professional conferences. Table 2.3 showed that I coded only six instances of proposals to recruit students from conferences. The three examples I reviewed showed a specific interest in minority student science conferences. For example, one REU site proposed attending the American Indian Science and Engineering
conferences while another attended the Wesleyan Conference on Recruitment of Minority Scientists. The third example was an REU interested in recruiting women from the Grace Hopper conference.

While infrequent, professional conferences for young minority scientists may be fruitful recruitment grounds. However, there will be a cost to attending and advertising at the conferences (i.e., renting a booth, paying for lodging, per diem). However, many of these conferences exist and they are likely magnets for the types of students that these REU sites propose to recruit.

**Conclusion**

The most general purpose of recruitment for REU programs is to generate a pool of undergraduate student applicants from which several are selected to join a research project with a professional researcher or scientist. As the first research question in this paper has shown (see figure 2.1), the recruitment recommendations described by the National Science Foundation are even more ambitious and aim toward an even more selective recruitment and selection process tied to the original and evolving goals of the REU funding stream. What this appendix contributes to the scholar and practitioner is a detailed look at proposed recruitment activities from a sampled set of REU sites spanning 30 years of REU funding. We can note with great certainty that REU sites have been proposing to recruit students from minority-serving institutions, leveraging distinct kinds of university partnerships (e.g., research collaborations, previous “agreements”), requesting help from organizations dedicated to broadening participation in the sciences, traditional methods, university diversity programs, personal and professional contacts, campus visits, and professional conferences.
From a pragmatic standpoint of conducting practical activity, this list of recruitment strategies can help REU practitioners brainstorm methods for student recruitment. The list and the information in the appendix offers a set of already proposed activities that REU sites find enticing or have found useful in the past.

From a scholarly perspective, very little was documented in the literature on the REU program, which included two program evaluation reports (Fortenberry, 1990; Russell and one scholarly article (Beninson et al., 2011). These authors discussed a set of recruitment practices that REU sites used to generate an applicant pool: internet (website, emails), what I called traditional methods (flyers, newspapers, magazines), conferences, campus recruitment offices, posting notices in their department, and having colleagues make announcements. Probably in large part because student recruitment was not a main focus of their research, these authors tended to generate lists that superficially described what these activities are. While a great first step to documenting recruitment practices, there is much room for improvement.

One major improvement in the scholarly understanding of REU or undergraduate recruitment practices arose from identifying patterns or similarities in recruitment practices and assigning practices to categories. Laursen et al. (2010) offered a distinction between formal and informal recruitment. They described formal recruitment as the social processes of recruitment that were not regulated by department-level official rules for student outreach and recruitment. Professors might recruit promising students from their classes or they might suggest a student to another professor. In contrast, they described formal recruitment methods as the rules and procedures that departments official used to recruitment students. These included advertising the research positions widely, moderate the stacking of high quality candidates with one professor only, and generally aiming for some kind of fairness in the recruitment process. By fairness, I
mean equal treatment of candidates: process whereby as many students were made aware of the position and each application was at least considered (but not necessarily accepted).

I believe that the formal and informal distinction drawn by Laursen et al. (2010), while insufficiently described to be applied other contexts, provides some traction for understanding Table 2.3. For instance, one would expect more informal or closed social networks to govern traditional methods of recruitment as well as the use of personal or professional contacts. As people tap their personal and professional networks, they are engaging in informal recruitment with the purpose being the recruitment of better student candidates. On the other hand, many of the other recruitment strategies appear to be of the formal kind: using professional conferences, university diversity programs, university partnerships and agreements, and recruiting from minority serving. These are formal in the sense that they are moving away from the personal networks that REU practitioners have and thus opening the REU recruitment process to a broader range of students.

The data from the Laursen et al. (2010) study came from four liberal arts colleges where faculty were selecting undergraduate students from their inside of their institutions to participate in research. The REU funding stream presents a different set of contextual features that will likely influence how recruitment activities should be understood and categorized. Below is a list of contextual features that are unique to the REU program and differentiate it from the research sites used by Laursen et al. (2010):

- Recruitment inside the REU host institution but also across the nation
- Existing federal infrastructure for recruitment
- A thirty-year history of operation
- Name recognition within the scientific community
• Public influence on the recruitment and selection recommendations because the NSF, as a federal agency, is under congressional oversight

• Student recruitment and selection recommendations may derive from NSF’s broader mission and agency objectives

• Individual REU programs are grant-funded and the federal grants typically last three years, but can be renewed

• The institutions that receive grants vary widely, including universities, research museums, and large laboratories

• The REU funding stream provides monies for upwards of 700 individual REU programs per year, offering a wide range of institutional and social conditions under which recruitment activities will occur

For example, the fact that REU sites are under some obligation to recruit outside of the host institution’s wall creates the conditions under which some recruitment effort must be expended on other institutions and professional networks. One research question that could help organize the body of recruitment practices is how do recruitment practices change when an REU site recruits inside and outside of its institution? Are some recruitment practices more likely to be proposed for external searches than from internal searches? Are informal recruitment practices more salient for internal searches?

In conclusion, this appendix advances the study of student recruitment and selection by documenting a taxonomy of strategies that REU sites have proposed for recruitment. The findings in this study will be useful for further studies. For example, it is now possible to note a

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14 See the REU Calls for Proposals document from 2013, “A significant fraction of the student participants at an REU Site must come from outside the host institution or organization, and at least half of the student participants must be recruited from academic institutions where research opportunities in STEM are limited (including two-year colleges).”
set of expectations for student recruitment strategies that REU sites will actually use. Given the prominence of the proposed use of minority serving institutions (MSI), it is possible to study what kinds of challenges and successes that REU sites encounter when recruiting from MSIs. It also possible to look at more nuanced practices such as if REU sites are leveraging partnerships with MSIs frequently or not. Lastly, even survey research can be benefit from this work. New surveys can delineate what may be a fairly complete set of recruitment strategies used by REU sites and collect frequency counts of the most common actual practices.
Need, Qualifications, and Diversity:

Constructing Student Selection Criteria at one Federally Funded STEM Summer Internship for Undergraduates
Abstract

Despite a growing interest in STEM undergraduate research programs and internships as mechanisms to enhance student learning and to increase retention rates in STEM degree programs, little research has directly examined how students are selected or hired into these programs. Selection criteria, how criteria are weighted, the content of program mission statements, how committee members understand the purpose(s) of the internship, the ways students present themselves in interviews, the background experiences of the selection committee members, and the particularities of a hiring context inform how students are chosen.

In this article, I examine the admissions process for one STEM summer internship at a federally funded laboratory in the western United States, focusing on how the selection committee constructed meaning from the selection criteria and how these criteria constructions were applied to the students. Using a discourse analysis approach and Burke’s terministic screens as a conceptual lens, I examined transcripts of the deliberations of science mentors at two meetings as they debriefed student interviews. The mentors discussed the merits of three students competing for two summer internship positions. Even though the internship was formally constructed as a needs-based opportunity, I argue that one student was admitted because of her perceived need for the internship and the second student based largely on her qualifications. Although student diversity was discussed by the committee, it played no obvious role as a selection criterion. The committee discussed the internship’s diversity mission in a defensive mode, employing legalistic terms. This is the first discourse analysis on student hiring for STEM summer internships.

Keywords: undergraduate internship, higher education, broadening participation,
Student selection practices for STEM undergraduate research programs and internships have gone understudied despite the fact that they are the principal avenue by which students gain access to these programs. Knowledge about selection processes is especially relevant when programs have mission statements that specify the ideal kinds of student candidates (e.g., talented, rising seniors, women). Scholarship on selection practices has the potential to identify practical difficulties and dilemmas that selection committee members face, to contribute to the scholarly understanding of student demographic patterns in program participation, and to help in the formulation of selection practices that lead to the outcomes that some STEM practitioners want, such as broadening participation.

STEM internships and undergraduate research programs, two somewhat similar types of programs, have recently figured into reducing student attrition and broadening the participation of members from underrepresented groups in STEM fields (National Academies of Science and Engineering, 2017; Laursen, Hunter, Seymour, Thiry & Melton, 2010). These programs are available to undergraduate students and may contribute to helping undergraduate students access graduate school through connecting students with practicing researchers and scientists, often for the summer (Russell, Hancock & McCullough, 2007). Undergraduate research programs and internships contribute to a student’s STEM advancement in at least three ways. First, they may serve to motivate some students to become aware of and pursue STEM jobs immediately upon graduation. Second, they may motivate students to apply to graduate schools because they want to access specific STEM professions that require graduate education (e.g. management positions, research careers). Third, if they target students from underrepresented groups, these programs can strengthen efforts to broaden participation in STEM fields.
In a small number of studies, scholars who study STEM undergraduate research programs and internships have documented a set of student selection criteria typically used by hiring committees. In a survey program evaluation of the National Science Foundation undergraduate research program, Fortenberry (1990) noted that summer science mentors used declared major, grade point average, courses taken, and academic advisor letters of recommendation to assess and select students. In an interview study of STEM faculty from liberal arts colleges, Laursen et al. (2010) learned that faculty tended to use three main selection categories for hiring students: student attributes (e.g., character traits and academic achievements), consideration for student groups that will benefit most for the research experience (e.g., gender preferences), and constraints on time and resources (e.g., limitations set on younger students). Laursen et al. also noted that there was a dynamic and fluid aspect to the selection process, which one faculty mentor likened to “an NFL draft” (p. 138).

Based on my research for the literature review, I am aware of no study that has analyzed data from a direct observation of the deliberations of a STEM undergraduate research program or internship selection committee that culminated in the hiring of students. Such a study has the potential to illuminate which selection criteria are most salient, how committee members understand the selection criteria, and how they are applied to students in an authentic context. As Laursen et al. (2010) suggest, if the selection of undergraduate students for summer research and internships positions is fluid and dynamic, a close-up study has the potential to shed light on the details of such a process.

In this study, I analyzed the deliberations of one selection committee as the committee members decided on two of three undergraduate student finalists for two summer STEM internship positions at a government laboratory in the western United States. The data are taken
from two audio recordings, one from each day’s deliberations. I used a discourse analysis informed by discursive psychology (Edwards, 2005; Potter, 2013) and Burke’s terministic screens (Burke, 1965) to explain how two of three students were selected. Findings will interest STEM education practitioners and funders of undergraduate research programs and internships.

This essay unfolds by first noting the policy context in which these kinds of program operate. Second, I discuss the available literature on selecting undergraduate students for research program and internships. Third, I provide an analysis of the data. I then discuss the findings and conclude with implications.

**Policy Context**

The apprenticeship model of involving undergraduates in professional research is a long-established practice in the U.S. Laursen and colleagues (2010) traced the apprenticeship model of undergraduate research in the U.S. back into the late 1800s. Merkel (2003) wrote that university-based undergraduate research programs started around 1968 at the Massachusetts Institute of Technology. In 1987, the NSF rebranded and restructured a preexisting undergraduate research program into the current Research Experiences for Undergraduates (REU) program (Doyle, 1987). Structured programs funded by government agencies further institutionalized, altered, and standardized some contemporary practices of undergraduate research. For instance, it is common for REU program sites to take place during the summer, to recruit students nationally, to have competitive admissions, to assign student to faculty mentors, to offer student generous stipends, and to require students to deliver research presentations.

Government-funded STEM undergraduate research programs and internships have multiple goals that generally fall into two categories. First, they seek to train and motivate undergraduate students so that they pursue STEM careers or apply for STEM graduate programs.
In theory, students are motivated to pursue STEM research careers after working on authentic research programs alongside practicing scientists (Fortenberry, 1990). An illustrative example is taken from the 2013 REU program Calls for Proposals grant writing guidelines:

The REU program] draws on the integration of research and education to attract a diverse pool of talented students into careers in science and engineering, including teaching and education research related to science and engineering, and to help ensure that these students receive the best education possible (p. 3).

Second, these programs have been leveraged to increase the demographic diversity of the STEM workforce through broadening participation initiatives (NSF, 2008). Both goals have potential implications for research on hiring undergraduate students for these summer programs and positions. What kinds of student qualifications do selection committees target as they aim to prepare undergraduates for the future STEM workforce? What role does race, class or gender diversity play in hiring practices? Once a program is established by an institution, is there an association between the purpose of the program and the types of students that are selected?

Literature Review

Selection and Hiring Practices Across Domains

The literature on hiring and selection practices is vast and covers an array of sectors including community college faculty (Flannigan, Jones & Moore, 2004), professional sports coaches (Collins, 2007), school teachers (Mason & Schroeder, 2010), undergraduate students (Golden, 2006), and research university faculty (Kayes, 2006). This scholarship also covers ethical issues in hiring practices such as affirmative action (Heilman, Blok & Lucas, 1992) and age discrimination (Bendick, Jackson & Romero, 1997). Ge"21e"1nate to this discussion are some of the findings that describe generalities in hiring practices across domains.
Hiring is a common social activity and many firms organize their hiring practices in a similar way. Wotruba and Castleberry (1993) offered a concise summary of the typical sequence of hiring practices. Hiring consists of a set of interrelated practices that connect in such a way that it is possible to hire one or more finalists for a job position. The authors wrote about four linked practices: job analysis, identification of job qualifications, recruitment, and selection. The job analysis refers to the determination of the goals and tasks that comprise a specific job. Next, firms typically identify a set of competencies or qualifications required of the candidate. Third, firms recruit candidates to fill an applicant pool. From the applicant pool, finalist candidates are chosen for the position through a selection process. Once a finalist is chosen and accepted, a hiring process is considered successful.

**Institutional Factors.** Researchers who study hiring and selection processes have focused on contextual and institutional factors that cause variations in hiring practices across employment sectors. Numerous local variations in institutional structures and composition create nuances in selection and hiring practices. For instance, Mason and Schroeder (2010) conducted parallel case studies in three school districts to learn how principals hired teachers. They learned that bigger school districts tended to have centralized hiring processes while principals in rural areas had more individual autonomy over who they hired. Some schools had collaborative hiring practices where human resource professionals and teachers were on selection committees. Other schools had centralized district offices charged with hiring.

In university settings, some scholars of undergraduate research programs have noted that the organizational arrangement of a university department becomes intertwined with how departments recruit and select students. Merkle (2003) observed two main organizing formats for undergraduate research programs in universities. First, she described informal recruiting and
hiring as when faculty and departments were charged with recruiting and hiring tasks. These recruiting and hiring practices were informal in the sense that there was not much university-level oversight or regulation and consisted of a lot of improvised human activity to find students. In contrast, formal student recruitment and selection tended to be organized in a central office where employees worked to match students and professions across numerous departments. Formal recruitment and selection was characterized by bureaucratic procedures, had formalized requirements, standardized applications for students, and often organized poster sessions or student symposia as capstone projects for student research experiences.

For discourse analysis studies, institutional factors are valuable to note because they can offer insights into why social activity is structured in a particular way or why actors discuss certain criteria more than others. For instance, the fact that this study’s laboratory was funded by a government agency, the National Science Foundation (NSF), certainly influenced the goals and priorities of the internship program. The goals of this laboratory strongly echo the priorities set forth by the NSF in its REU program. However, the analytic focus of this study is centered on how selection committee members make sense of and apply selection criteria. I now shift to reporting on social psychology studies that examine how hiring and selection criteria are interpreted and used by actors in authentic hiring contexts.

**Criteria Used in Selecting Candidates**

**Fit.** Rivera (2012) studied the hiring practices of firms as they recruited recently graduated undergraduate students from the most selective U.S. universities. She investigated the extent to which the hiring process was more like a practice in matching student candidates with a firm’s culture as opposed to strictly comparing students on their qualifications. Drawing on data analyzed from over one hundred interviews of professional staff and consultants who worked
annual hiring events for firms, she found that undergraduate candidates were often evaluated based on their preferred leisure activities, life experiences, and how they presented themselves to the hiring evaluators. Firms formally included “fit” as a selection criterion in their assessments of students. Fit referred to how well a candidate might adapt, assimilate or flourish within a firm’s perceived work environment.

To assess a candidate’s fit, hiring consultants compared themselves to the students by asking self-reflexive questions like, “Would I want to work this person?” or “Would I want to be stuck in an elevator with this person?” Rivera (2012) found that the hiring consultants’ personal history and intuitive assessment of the candidate influenced how the candidate was finally evaluated. For example, hiring consultants from Ivy League universities were less understanding of candidates who graduated from state universities. On the other hand, a hiring consultant who graduated from a state school assessed a state school interviewee more favorably or at least did not count the candidate’s alma mater as a negative.

Rivera was not the first to notice this idea of cultural “fit” as a selection category for candidates. Twombly (2005) investigated hiring practices in community colleges. Twombly found that fit could trump educational qualifications for hiring community college faculty. For one selection committee at a rural community college in the Midwestern U.S., a candidate from either the East or West Coast who possessed a PhD and applied for a teaching position was viewed with suspicion. Community college administrators doubted that this potential hire would be happy or stay at the rural institution. In contrast, a candidate from the college’s region who had a master’s degree was viewed more favorably. In this case, fit was tied to perceptions of a candidate’s long-term commitment to the position.
**Merit.** Through interviews and observations, Posselt (2016) studied how professors in different departments at six top U.S. universities admitted graduate students. Because she looked at several departments and disciplines, she noted variations in how department faculty understood and assigned merit to student candidates. She found that traditional forms of merit (e.g., grades, test scores) did not have a rock-bottom or obviously shared interpretation either across the graduate schools or among professors within a single department. While many departments emphasized GRE test scores, science departments used different threshold test scores for domestic and foreign students. For instance, domestic applicants could have lower test scores than foreign-born applicants because committee members raised concerns about the interpretation of test scores for foreign students. For one, a single high cut-off score would have the effect of stacking the applicant pool with a high concentration of foreign-born Asian students who tended to, on average, have higher GRE scores than U.S. students. Second, several professors were concerned that some Asian countries permitted cheating on tests or overemphasized test taking skills to the deficit of other valuable abilities (e.g., creative thinking, persistence in the face of failure).

**Diversity.** Posselt (2016) also studied how university graduate school selection committee members used diversity as a selection criterion. She found that diversity was discussed much less than other qualifications. When it was used, it often took the place of a tie breaker between candidates where, all else equal, the candidate who matched the diversity criterion would receive the offer. Like the case of qualifications, Posselt observed variation across and within departments in how individual people interpreted what diversity meant and what kind of diversity was valuable. Diversity could be rooted in race, gender, ethnicity, geography or socioeconomic status. In some cases, professors might admit students because the
university offered diversity scholarships. Lastly, diversity was almost never a stand-alone criterion for selection. More commonly, diversity became a salient selection criterion at a more mature stage in the selection process, after merit criteria were applied and a large portion of the student applicant pool were rejected. Hiring committees commonly spoke of excellence in diversity. Excellence in diversity referred to cases where a student was from a demographically diverse group and had an outstanding academic record. Particularly in the case of the science disciplines, selection committee members felt that students from demographically diverse backgrounds and had strong academic records were being courted by other institutions. Admitting a student who was less likely to accept the offer was risky; it was better to admit students who were likely to accept. Stevens (2009) also found that university admissions officers perceived that academically strong students from diverse backgrounds were in high demand across elite U.S. universities.

In summary, social psychological research on hiring and selection practices has produced interesting findings. One of the most important findings is that when research highlights the human role hiring practices, breakdowns in uniform hiring practices become more evident. That is, despite the best efforts of hiring committees to structure hiring practices, they may disagree about or interpret differently how the relevant job qualifications map onto candidates or how to best compare the merits of one candidate to another. Stated in even stronger terms, a fair hiring practice ought not be affected by who is doing the hiring. Yet, social psychological research on hiring practices shows that whoever is in the hiring room may influence the hiring outcomes.¹⁵

¹⁵ I do not mean to suggest something like a female-only selection committee would only select other women. However, as the Rivera (2012) case of evaluating the quality of a university shows, hiring consultants from state schools did not hold attending state schools against candidates. In contrast, hiring consultants from Ivy League schools did. How widespread these kinds of attitudes are and why people hold them are empirical questions.
Student Selection in STEM Undergraduate Research Programs

Two studies offer insight into student hiring processes for STEM undergraduate research programs. The first is a program evaluation report from the first three years (1987-1990) of the National Science Foundation’s (NSF) Research Experiences for Undergraduates (REU) program (Fortenberry, 1990). The second was an interview study of seventy faculty members at four liberal arts colleges who conducted summer undergraduate research programs at their respective institutions (Laursen et al., 2010).

The NSF evaluation of the REU program contained information from an analysis of surveys from 1,028 REU site and supplement awards and survey responses from 1,953 student participants from the first three years of the REU program, 1987 to 1990 (Fortenberry, 1990). The report concluded that staff who operated REU sites tended to select students by looking at letters of recommendation, grade point average, declared major, grade point average, prior coursework, and if students were members of underrepresented groups in STEM fields. REU site awardees tended to emphasize advisor recommendations, grade point average, and underrepresentation status more than REU supplement awardees. Fortenberry found that REU site operators from engineering and computer science NSF directorates said they took diversity, defined as a student’s underrepresentation status, into account more than other NSF directorates, such as geosciences and math and physical sciences.

Laursen et al. (2010) interviewed seventy faculty members who were either active mentors for undergraduate research programs at small liberal arts colleges or had done so in the past. The authors organized faculty comments on student selection criteria into three broad

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16 REU supplements are NSF awards that researchers with existing NSF research grants can apply for to provide an opportunity for undergraduate students to work with them. Sites, on the other hand, are undergraduate research programs for a small cohort of students.
categories: student attributes, student group preferences, and departmental and individual constraints. Student attributes were perceived character traits (e.g., attitudes, personality) and traditional markers of merit (e.g., grades, past laboratory experience). Student group preferences referred to the sociodemographic groups that received preference in the selection process (e.g., women, minorities). Third, individual and departmental constraints referred to caps placed on the applicant pool for students who might be a burden (e.g., younger student candidates). In descending order of frequency of mention in the interviews, the faculty discussed student attributes, followed by preferred student groups, and, third, departmental and individual constraints. Constraints were largely mentioned by faculty for the elimination of students.

Because the Laursen et al. (2010) study was based on interviews (as opposed to surveys), they were able to analyze intersubjective complexities raised by the interviewed staff and faculty. When discussing the attributes of students, science faculty and mentors used student attributes to positively and negatively evaluate students. For example, perceived student tenacity, defined as the willingness to persevere in the face of setbacks, was a favorable trait. Additionally, dependability, a desire to do independent work, willingness to take risks, curiosity, and viewing challenges as fun were also positive student attributions. Some advisors believed these character traits were more important than good grades or success in coursework. In contrast, students who did not demonstrate enthusiasm, who appeared to be passive learners, who seemed to not think deeply about issues, and who were perceived to be interested in leveraging the research experience to build their résumés tended to be weeded out. Faculty who used grades and coursework as selection criteria often inferred character qualities from these markers of merit such as a diligent work ethic and intelligence.
Similar to the Posselt (2016) study, Laursen et al. (2010) noted that demographic diversity was used by science faculty when choosing student researchers. When selecting students based on group membership, science mentors spoke about including students who might benefit the most from the research experiences. Included in this category were women, minority students, applicants from schools with limited research opportunities, and first-generation college students. Some amount of gender preference in favor of women was openly practiced by most of the university departments represented in their data. Department faculty took a particular attitude toward selecting women. They noted that women were no longer underrepresented in many STEM fields and that many women were academically stronger than male students. They justified selecting women on the grounds that it increased their academic self-confidence and helped prepare them for competitive graduate school admissions.

The Need for this Study

There are three points that contribute to the unique value of this study. First, complex social phenomena ought to be investigated using a range of methods. Large scale surveys (Fortenberry, 1990; Benninson et al., 2011) and interview studies (Laursen et al., 2010) of student selection processes produce valuable findings. However, additional perspectives and methodologies, such as discourse analysis, provide additional insight into the selection process. Specifically, discourse analysis has the advantage of highlighting contextual contingencies and social dynamics that are unlikely to be captured in surveys and interview studies because they do not rely on first person accounts, the memories of study participants, or the coherent narrative structure that tends to accompany human recounting of past events.

Second, funders like the National Science Foundation often make student selection and recruitment recommendations that align with their missions or program goals. Discourse analysis
studies offer insight into how practitioners make sense of these recommendations and enact them in practice. Funders can learn about areas of confusion, opposition, and compliance that characterize the practitioner experience.

Lastly, the wider scientific community can learn from studies of student selection into internships and undergraduate research programs. One of the most significant differences between internships and job market hires is that internships and undergraduate research programs carry with them an understanding of selecting students based on educational reasons. That is, these students are not being hired as full time employees but rather because these programs are an opportunity for advanced training, inspire them to pursue STEM careers, and may motivate them to complete their degree programs. Observing how a program’s educational purposes influence recruitment and selection may be of general scientific interest for researchers interested in recruitment and hiring.

Methodology

Using discourse analysis, I analyzed the talk of one ad hoc selection committee as they deliberated the relative advantages and disadvantages of hiring two of three undergraduate candidates for a summer internship at a government laboratory. Discourse analysis was an appropriate methodological choice because the data were transcriptions of the two deliberation sessions. The literature review also suggested that selection criteria and their application are subject to the idiosyncrasies of committee members. This suggests a need for studies that look more closely at how these idiosyncrasies unfold in the selection process.

Research Questions

1) What does selection committee talk reveal about how participants chose the undergraduate finalists?
2) How did the three committee members come up with and operationalize student need and qualification as selection criteria? How did these selection categories help them to accomplish the selection work?

3) Given that one of the purposes of the internship was to address underrepresentation in STEM fields, how did the committee members discuss and use diversity as a consideration for hiring?

Data Sources

Prior to conducting this study, I spent two summers at the government laboratory conducting program evaluation work. The two evaluation reports were case studies documenting student experiences in the internship. To complete this work, I spent dozens of hours across the two years conducting ethnographic observations. Having spent extended time at the site, interviewing the students, writing up the reports, and having candid conversations with the program director about my findings enabled me to more richly interpret the transcription data.

Several departments at the government laboratory were interviewing and evaluating students during the week that I recorded the student deliberations. I was able to attend and record five deliberation sessions from three departments. I chose to analyze the transcripts from one department for this study because I was able to attend both of their deliberation sessions and thus able to follow a complete thread of the final stage of student selection.

The raw data consisted of audio recordings from two sessions of the same three individuals who made up the internship selection committee for one department (two audio recordings in total). Two of the individuals were male computer scientists who worked as
programmers who worked for the government laboratory. They worked directly with student interns as science mentors. The third person was the female program director for the summer internship. She oversaw the management of the internship, the supplemental educational and social activities that students attended weekly, the student recruitment process, and organized the student selection process. All three research participants were STEM workers or had STEM research backgrounds at either the bachelor’s or master’s level, but not Ph.D. The three student candidates, Tristan, Constance, and Gloria (pseudonyms) were undergraduates at different universities around the United States. I did not learn much about their college careers or personal lives from these data. Tristan and Constance were interviewed on Day 1 and Gloria was interviewed on Day 2.

The first audio recording was twenty-one minutes and forty-six seconds long. In this first recording, the committee debriefed the interviews of two students because they had scheduled two back-to-back Skype interviews. The second audio recording was twenty minutes and fifty-six seconds long and contained a discussion of the third student candidate. The second recording also contained a discussion on the final rankings of the three student candidates. The first transcript contained 3,659 words and the second had 4,123 words. I transcribed both audio recordings and utilized Olakivi’s (2013) transcript technical notation for sections included in this analysis (see appendix A for transcription notation).

**Analysis**

I began the analysis by listening to the audio recordings repeatedly as well as reading through the transcripts multiple times. During these data review sessions, I familiarized myself with the data and began to develop conjectures about how the selection committee eliminated
one student. My early impression, which I further developed through subsequent analysis, was that the selection committee had used the term “need” in two different senses while discussing the two final hires. Collecting and reviewing the cases where “need” was used provided concrete examples of the two distinct ways that the committee members were constructing the purposes of the internship.

I built on this initial insight by using terministic screens (Burke, 1956). For Burke, terministic screens are the various ways in which words channel attention or awareness towards and away from ideas, interpretations, and emotional responses. Language use has rhetorical consequences for how human beings understand and interpret a situation or phenomena, much like how different filters on photographs influence how and what we see in a picture. One clear-cut example of how terministic screens channel human attention and emotion is in the case of terrorism and liberation groups. A newscast can view an insurgent group as a terrorist organization and use certain language to persuade the public of this interpretation. On the other hand, a newscast could view the insurgency as a liberation movement where the state is the enemy. Even though they are discussing the same insurgent group, these two newscasts would signal their positions by certain terms and rhetorical devices. These clusters of terms constitute the terministic screens.

In the case of this study, the terministic screens are basically two distinct clusters of words that committee member used to describe the internship or the students. Because the topic of the committee’s discussion was the internship and the committee members did not change from Day 1 to Day 2, it was possible to note how the terministic screens changed from the Day 1 deliberations to the Day 2 deliberations. This is to say that the committee members looked at the
internship in two different ways. I identified need in both terministic screens, but the meaning and use of the word need changed from Day 1 to Day 2.

Diversity, on the other hand, was used once during the dialogs. I included the term in this study because of the important role that diversity has recently assumed in national STEM discourse (NSF, 2008). Additionally, reducing underrepresentation was one of the internship’s twin goals.

After deciding on analyzing the transcripts by looking at need, qualifications, and diversity, I collected the excerpts where these terms and their synonyms were used or discussed and focused my analysis more carefully on those segments. Some of these segments ultimately came to be included in this paper. Even though I studied those segments more carefully, I returned to reading the transcript sections before and after the segments to be sure I was not omitting any critical context and social interaction that would help in making sense of the data.

**The Research Site and Selection Process Overview**

The research site was a government laboratory in the western U.S. that was sponsored by the National Science Foundation. The laboratory dedicated a large portion of its resources to studying atmospheric and environmental change over time and across the continental U.S. While much of the laboratory engaged in science and engineering work, the education department worked on community engagement, citizen science, and operated a summer internship for undergraduate students. I was hired during the first two years of the internship’s operation to conduct a program evaluation of the internship program. The current study took place at the beginning of the internship’s third year. By the time I had envisioned this study, I knew many of the science mentors, had done over twenty hours of ethnographic observations of prior interns,
and had developed professional ties with the head of the education department and the program director of the internship.

The generic selection process outlined in the literature review generalizes well to the internship hiring process for this government laboratory and fits within what I described earlier as a formal system. Typically, around October the program director recruited laboratory scientists to be mentors and the scientists designed job descriptions for the summer internship positions. In November, the program director began national student recruitment. By late February or early March, the laboratory stopped collecting student applications. After the closure of the application process, the mentor teams, who typically worked in specific departments (e.g., cyberinfrastructure or engineering), reduced the applicant pool to three finalists. These finalists received invitations to Skype interviews. A day or so after the last interview, the student finalists were contacted with offer letters. The program director worked closely with the human resources office to send out acceptance letters, hire students for the summer, and incorporate them into the work environment, a process called “onboarding”. Students typically arrived at the laboratory in late May.

I investigated the final stage of the selection process: the selection of the student finalists. I do not have much information on how the larger applicant pool was whittled down from an average of ten to fifteen applicants per department (roughly ninety students applied to the internship) to the final three. I suspect that quantitative variables featured prominently in the sorting of the applicant pool where grades and advanced coursework counted in favor of students and low grades and entry-level coursework generally counted against them.
Findings

Summary of the Deliberations

On Day 1, two internship candidates, Tristan and Constance, were interviewed. The committee’s deliberations on Day 1 generally took the form of comparing and contrasting Tristan and Constance to each other and evaluating them against selection criteria. What exactly the abstract criteria meant, how they were defined, and how they were applied varied throughout the committee’s deliberations and appeared to be inconsistently applied to student candidates. For example, Constance did not have a previous guided research experience, but Tristan did. As I will show in detail below, the prior work experience counted against Tristan because of a construction of the internship as an educational opportunity for Constance.

On Day 2, the committee interviewed the third and final undergraduate candidate, Gloria. At the end of the second day, following the deliberation after Gloria’s interview, the selection committee confirmed that they would offer one position to Gloria. This left the final spot for either Tristan or Constance. In effect, since Day 1, Tristan and Constance were in competition with each other and Gloria’s success on Day 2 intensified their competition for the remaining position. In the committee’s deliberation between Constance and Tristan, six points were raised that favored Constance: equipment at the laboratory would complement her academic interests, she appeared passionate about the position, she was a “big picture” thinker, she lacked prior research experience, she appeared to care about the particular instruments used in the laboratory, and some committee members suspected that she and Gloria would get along well. For Tristan, three points appeared to count against him in the committee’s final analysis: Tristan expressed that he did not enjoy math, that he tended to procrastinate if he did not enjoy a task, and he was perceived by the program director as “arrogant” about his tendency to procrastinate. In line with
my previous observation that criteria were erratically applied, committee members noted that Constance also self-described as a procrastinator, but they did not openly hold this against her. From my analysis, I never learned why the committee showed some inconsistency in their application of selection criteria across the students.

With this overview of the Day 1 and 2 selection committee deliberations, I can now turn to a more detailed analysis of need, qualifications, and diversity. The following sections contain headers for need, the two terministic screens, and diversity but not qualifications. The findings for qualifications are embedded within the findings and the discussion.

**Multiple Meanings of Need**

Perhaps the central finding in this study was that the word “need” was used and applied to the undergraduate candidates and internship in two distinct ways. On the one hand, a student could need the internship. To committee members, this need meant that the internship had something important to offer the student for either academic growth or career development. While the three committee members explicitly converged on the idea that one way the internship should be distributed was based on need, each committee member had a slightly different take on what need meant. Scientist 1 tended to view the internship as an offering and considered giving the internship to the student who could benefit the most. Scientist 2 tended to view need as an opportunity to advance a student’s professional career in the direction of a STEM career. The program director once discussed how in the prior year an internship position was given to a student based on need. In the previous year’s case, need was defined as a student coming from a liberal arts college without a strong STEM program. The competition between Constance and Tristan for the internship position was predicated on this type of need.
In a second sense, the committee implicitly showed that need also referred to the internship itself. That is, the organization had “needs” that the intern could fulfill. The idea was that a student could contribute to the work projects at the internship and that the highest qualified student might be in the best position to do so. Unlike the previous case of need, when the committee talk turned to discuss how Gloria would be an asset to the internship, the committee did little work reconstructing the internship in a new way. There was almost a tacit understanding among the committee members that they were discussing a second, distinct construction of the internship.

The second significant finding was that each construction of the internship was associated with a different cluster of descriptive terms. Burke’s (1965) terministic screens were useful here. If one compares the terms used by the committee to describe the internship from Day 1 to Day 2, from the deliberation about Constance and Tristan’s competition to the deliberation about Gloria, there are noticeable differences. In Constance’s case, she needed the internship. In Gloria’s case, the committee needed Gloria. For Constance, the internship was described as an offering and educational opportunity. For Gloria, she was a “slam dunk” of a candidate and a good fit for the department’s culture. Because it was used in the Day 1 and Day 2 deliberations in two different senses, the word need formed a kind of conceptual bridge linking the two internship constructions. By directly comparing the usage of need from Day 1 to Day 2, the different internship constructions became salient.

For the sake of clarity, I label the Day 1 terministic screen as the “opportunity-based terministic screen.” This terministic screen is most related to the cases of Tristan and Constance. I label the Day 2 terministic screen as the “qualifications-based terministic screen.” This terministic screen is most related to the case of Gloria.
Building the Opportunity-Based Terministic Screen

The act of verbally defining need was part of the work that the committee did to select the finalists. Segment 1 was the first piece of dialog that I captured with the audio recorder and already the program director had framed the internship as useful to Tristan’s career trajectory and professional growth. The program director initiated a framing of the internship as an opportunity to advance a student’s career. “Expose” was one word in the terministic screen that focused the committee’s attention toward understanding the internship as a developmental opportunity for these students.

Segment 1 (00:00 – 00:25)

PD: (the recording began mid-sentence) client side (.) so doesn’t really know the application (.) um (1.0) big picture of it as well but he’s really on the technical side (1.0) so for him an internship like this would be great to expose him to the (.) how this could be useful where it fits and all

Scientist 2: //absolutely

PD: probably no question// can handle anything you throw at him as long as you interest him (1.0) which worries me a little bit I have to admit

Segment 1 begins to show speech acts that reveal where the committee’s attention is directed. The program director noted that Tristan’s strength was that he was technically competent but that he did not understand how his skills fit into a larger, organizational work flow. In a section of dialog following segment 1, Tristan was contrasted with Constance who was seen as a “big picture” thinker, someone who might be better at understanding the broader process within which technical tasks fit. Rather than being counted against him, his perceived deficiency was inverted by the internship’s framing as a useful opportunity to “expose” him to something new. Discussing a student candidate’s weaknesses as reasons for choosing them directed the committee toward choosing a candidate based on potential benefit to the student.
This type of inverted assessment would be re-invoked by selection committee members as they spoke about Constance.

Note that not all weaknesses were converted into reasons to select a student. The program director was not willing to accept something that she perceived as a character deficiency, namely that she thought Tristan would not work on tasks if he was not interested in them.

In segment 2, the committee strengthened the construction of the internship as a developmental or training opportunity for summer interns. Scientist 2 introduced a vignette from his time at the university as evidence for how a research program or internship could shift one’s interest and skillset toward computer programming. Scientist 1 recounted a developmental episode from his personal history that showed that computer programming was central to science in contemporary times.

Segment 2 (00:53 - 1:25)

Scientist 2: you do and (. ) in her case (. ) in Constance's case (. ) um (. ) it may just be (. ) so she's a sophomore (. ) she may just not have had that experience (. ) //or in
PD: right//
Scientist 2: my own research experience when I was an undergrad I (. ) I knew nothing about programming and =
PD: okay ((brittle short laughter))
Scientist 2: //and now I'm a software engineering
PD: that's all you do// (group laughter)
Scientist 2: that experience (. ) uh (. ) forced me to learn and forced //me to
PD: right//
Scientist 2: so I think that would be valuable for (. ) for Constance
PD: um hum
Scientist 2: um yeah
Scientist 1: yeah that's a good point (. ) she might get more out of that piece (. ) I came in through that same route (. ) I want to be a scientist then you find out later that oh no if you want to do science you'd better be a programmer (. ) So
Scientist 2: yeah, so
PD: but (. ) I don't doubt she can (. ) I really get the feeling that she could do it (. ) //she’s quiet
Scientist 2: I think so//
The focus of segment 2 continued in the direction indicated by segment 1. In the first talk turn, Scientist 2 articulated the perception that, because of her sophomore status, she might not have had the computer coding experience that would be required to complete the summer internship task. He followed up this assessment with a personal account of how his undergraduate research position pushed him to not only learn coding but toward becoming a software engineer. In this context, Scientist 2’s anecdote operated as a piece of evidence in favor of Constance’s selection, that the summer internship might be a powerful enough experience to move her trajectory toward science-related computer programming. Scientist 2 built on the opportunity-based screen when he said, “I think [the internship] would be valuable for Constance.” The internship as *valuable* is the key phrase that fits inside the opportunity-based terministic screen.

Following this last quote, Scientist 1 further built up the opportunity-based terministic screen when he said that Constance “might get more out of that piece.” By including the comparative adverb “more” in his statement Scientist 1 suggested a comparison between Constance and Tristan where Constance would gain more coding experience exactly because the program director had earlier deemed Tristan to be technically proficient. Constance, because of her lack of experience, stood to gain more from the internship. This is a second example of the inverted assessment that characterized Day 1 committee deliberations.

The second-to-last talk turn in segment 2 from the program director seemed out of place compared to the way that the committee had been discussing Constance so far. The program director appeared to counter a concern that was not raised by anyone: that Constance might not be able to learn to code quickly enough to complete the summer work. The problem for Constance, and for the opportunity-based terministic screen, was that if they continually built up
Constance as much less capable than Tristan, they might have reason to doubt her ability to do the internship task. While the committee seemed committed to assessing which student would benefit the most from the internship, I doubt they would want to pick a student who was unlikely to complete a summer work task. In fact, the program director would have remembered a case in a previous year when a student had difficulties completing a summer project. This student became a time sink for her science mentor.

In segment 3, committee members engaged in direct comparison between Constance and Tristan based on the program director’s question about which of the two students knew more about using a spectrometer, a piece of equipment used frequently in this department. This segment is valuable because it showcases the inverted nature of the competition on a single qualifications criterion.

Segment 3 (4:01 – 4:55)
Scientist 1: that is (. ) that's a valuable piece we offer if (. ) okay you've learned the theory but how does it (. ) how does the rubber meet the road ((only he laughs))
Scientist 2: yeah
PD: who do you think has a little more (. ) understanding of (. ) spectrometer?
Scientist 1: // ((Blows air out of mouth in a thoughtful but loud way))
Scientist 2: I think that (. ) // it's tough cus she's obviously learned (. ) ok I think she’s learned about it in her coursework is kind of (. ) what what I got out of that
PD: where was (. ) that (1.0) I'm trying to
Scientist 2: in her essay number one she mentions
PD: ok we didn't give her a chance to talk about it
Scientist 2: well she mentions an interest in doing spectrometers (. ) and uh (1.0) and (. ) yeah (. ) as it relates to astronomy and
PD: oh that's // right
Scientist 2: and that sort of thing //
PD: but it wasn't like a real-world application per se it was // through labs
Scientist 2: right //
Scientist 1: yeah.
Scientist 2: whereas whereas
Scientist 1: yeah, intro to astro had the spectroscopic boring work
Scientist 2: whereas Tristan has (. ) done some image (. ) algorithms and analysis
Scientist 1: I was impressed that he queued up a demo for us
In the beginning of this segment, Scientist 1 spoke again about what “we” can “offer.” I understand the “we” to variably and at times, interchangeably, mean the internship staff, the government laboratory, and the mentoring the selected candidate will receive. The offering he noted was a departure from schoolbook learning toward real-world learning where “real-world” seemed to indicate non-theoretical practical experience with equipment. Because Tristan had already experienced undergraduate research, Constance was seen as a better fit for what the internship might provide. Key to understanding how this advantage was conferred to Constance was in the program director’s commentary that Constance’s prior learning about the spectrometer was not “a real-world application” while Tristan’s prior research experience was.

The spectrometer discussion clearly highlighted the distance between the current construction of the internship and a traditional qualifications-based competition for a hiring position. If proficiency or skill was of primary concern, then Tristan would have won out over Constance because he had prior spectrometer (or something similar) experience. The committee had a reason to believe that Tristan could operate the instrument or understand its data faster than Constance. However, the committee was examining the student who would gain the most value from the internship and Constance was awarded an advantage because she was perceived to have only book and laboratory knowledge of the spectrometer.

Segment 4 advances the analysis one step further by showing Constance was the more desirable candidate of the two, thus further cementing the direction in which the opportunity-based terministic screen had been building. The selection committee employed the term “need” explicitly as well as offering a series of other terms that represent the opportunity-based terministic screen being used to construct and describe the internship.
Segment 4 (6:00 – 6:32)
Scientist 2: and even though (. ) even though he's got the more directed experience with that?
PD: um hum
Scientist 2: that might the reason to go for (. ) //someone who doesn’t
PD: her (. ) right//
Scientist 2: //because she needs it
PD: because she needs that// I agree
Scientist 1: we can offer that experience
PD: right right
Scientist 2: that's (. ) that's (. ) it's tough you want someone who's really qualified but also (. ) it's an //educational thing.
PD: this is a learning opportunity // for them
Scientist 2: yeah.
PD: thank you for saying that (directed to Scientist 2) because you really get that (. ) // I appreciate it
Scientist 1: in some ways it's something we can really offer (. ) // accrue a benefit from it most

In segment 4, it is possible to observe some of the terms used by each of the committee members that constitute the opportunity-based terministic screen. The constellation of terms consisted of “offer,” “benefit,” “educational,” and “learning.” By minute six in the dialog, many of these terms had developed some history of use. In segments 3 and 4, Scientist 1 mentioned three times that the internship could “offer” whatever Constance lacked. Across segments 2, 3, and 4, Scientist 2 referred to how the internship could be “valuable” to Constance to catalyze her along a STEM pathway and to motivate her to pursue computer programming. These linguistic repertoires, which continued to form over the Day 1 deliberations, set the stage for distributing the internship opportunity based on need. However, until this point in the dialog there had not been a formal, social recognition that the internship was a learning or educational opportunity for the student who could benefit the most.

In segment 4, several talk turns demonstrated that the committee members had arrived at an agreement of the internship as a learning opportunity. Talk turns 9-13 show the committee cohering around an understanding of the internship. Scientist 2 noted that qualifications and
educational need were considerations for hiring a student but that they were somewhat in tension. That is, he did not attempt to suggest that they were two sides of the same coin or that a compromise could be discovered. His comment left open the door for hiring a student based on qualifications but the discussion up to this point had produced a framing of the internship as one that should address needs or provide maximum benefit to the chosen intern. Following Scientist 2’s talk turn, the program director declared that the internship was a learning opportunity for the interns and, in her next turn, thanked Scientist 2 for acknowledging the educational purpose of the internship. Toward the end of the Day 1 deliberations, the program director would reinforce selecting students based on need by declaring a selection rule, which was to choose a student based on his or her “needs.”

Returning to the bigger picture of how the committee used language to accomplish the hiring work, one way to understand the case for selecting Constance over Tristan was that the committee perceived that she would benefit more than Tristan because she did not have a prior research experience or have “real-world” experience with the spectrometer. Because of his prior research experience, Tristan was being positioned as someone who would not benefit as much from the internship.

**Building the Qualifications-Based Terministic Screen**

At the end of the Day 1 deliberations, it looked as if Constance had a clear lead over Tristan based on the committee’s growing perception that she would benefit from the internship more than Tristan. The construction of the internship appeared well established and understood across the three committee members. Yet, the Day 2 deliberations showed a strong discontinuity in the construction of the internship and a building of a different terministic screen to describe
Gloria and the internship. It was Gloria’s strengths, not her weaknesses, that would impress the committee.

Just as in segment 1 which marked the opening of the first deliberations on Constance and Tristan, segment 5 was the opening dialog about Gloria. The initial conversation was dominated by positive references to Gloria’s personality qualities. Listening to segment 5’s audio recording revealed a heightened tone of excitement in the voices of the committee members.

**Segment 5 (00:03 – 00:31)**

**PD:** alright (1.5) was she as good to you as (. ) your interpretation as she was for me?

**Scientist 2:** //oh yeah I think (. ) I was really impressed

**Scientist 1:** // yeah oh yeah //

**Scientist 1:** yes

**Scientist 2:** yeah (. ) I was very impressed.

**PD:** I think she’s a little bit of a (. ) an actor (laughter)

**Scientist 1:** well but // I like that

**PD:** I like it (. ) I know //

**Scientist 1:** we need that

**PD:** she's an amazing storyteller

**Scientist 1:** you don’t totally // want

**Scientist 2:** yeah //

**Scientist 1:** the head down coding only keyboarder (. ) at least not in our group (. ) we have to work with too many different people and too many different teams so I (. ) I like that

Visible in segment 5 was the convergence of positive opinion on Gloria. The three committee members spoke highly of her. The committee members did not use words like “amazing” or “impressed” when discussing Tristan or Constance. Toward the end of the segment 5, Scientist 1 spoke about how he thought Gloria’s personality was a good fit for his department because teamwork and interaction were important aspects of his department’s work. He did not want a “head down” computer programmer type. It is unclear but possible that this favorable attribution to Gloria implicitly counted as a negative against Tristan who was positioned as a “programmy guy” during the Day 1 deliberations (not shown in the segments presented here).
Scientist 1 was also the first to use the term need to refer to how his department or working group prefers candidates who have interesting personality traits, such as Gloria’s storytelling.

When compared to the Day 1 deliberations, what is notable in segment 5 is the absence of reference to Gloria’s perceived weaknesses or how the internship could be valuable or be a learning opportunity for her.

In segment 6, the committee members continued building the case for hiring Gloria because of her qualifications. They suggested that her work history as a teacher’s assistant was valuable and her prior experience working with “ghosting artifacts” or sensor malfunction were reasons to choose her.

Segment 6 (00:45 – 1:58)
Scientist 1: anyone who's willing to jump in and do a teaching position
PD: // Yeah
Scientist 2: being // (.) having a (.) teacher's assistant position but really (1.0) I had a (.) a great I had a great professor in college that told me that if you can't explain it to someone (.) then you don't really know it ((laughter))
PD: // Yeah
Scientist 1: yeah exactly //
Scientist 2: I think that kind of experience is (.) is (.) pretty solid (.) I think so
Scientist 1: I'm excited that anyone who really does teach (.) I mean (.) I did training for fifteen years at ((inaudible)) so I'm partial biased on that (.) I was psyched to see that (.) that's (.) that’s a big // plus
PD: and that // ghosting (.) dealing with the ghosting artifact (.) and (.) trying to (.) process the data to get rid of that? (.) it's like ok she's already halfway? there? on this job (.) // right?
Scientist 1: that’s // yeah and (.) that’s (.) I think that's a part that gets missed in a lot of cases? (.) you got taught this abstract thing that sensors always work perfectly and it's about analyzing the data (.) and then you (.) when (.) when (.) when you're forced to work with a sensor you realize how imperfect they // are (.)
PD: um hum //
Scientist 1: and I like this (1.0) this is someone who already appreciates that and maybe can help us to address (1.) // ours
PD: yeah //
Scientist 1: we keep finding these weird quarter cases (.) like oh
PD: what's that?
Scientist 1: we need another step to take care of that thing. So (1.) I think that would be a // good fit with project //
PD: // that's amazing // experience to come in with (.) right?
Scientist 1: yeah (.) yeah

Even a cursory reading of segment 6 shows how the committee favorably took to Gloria. The committee favorably evaluated her prior experience teaching and working with sensors. Scientist 1 appeared to appreciate that Gloria understood the pragmatic realities of working with data collection instruments. What is less obvious is how differently the internship was constructed from the previous day. The opportunity-based terministic screen from Day 1’s internship was being replaced by a qualifications-based screen that was comprised of a new set of phrases and words. For instance, the program directed noted that “she’s already halfway there on this job,” indicating that the committee was hinting that the internship-as-a-learning-opportunity was now an internship-as-job. Scientist 2 suggested that Gloria “already appreciates” how the imperfect functioning of sensors and that maybe Gloria “can help us to address” their sensor issues. In the second-to-last talk turn, the program director stated that Gloria’s experience with sensors and ghosting artifacts was “amazing experience to come with.” Day 2’s construction of the internship was rapidly drifting toward a job hiring situation and Gloria’s fit to the internship was assessed positively both on her personality and her prior qualifications.

One point of contrast between Day 1 and Day 2 deliberations was that while Tristan’s prior experience counted against him, Gloria’s counted in her favor. In segment 6 there is no evidence of an internship construed as a developmental or learning opportunity for Gloria. In fact, Scientist 1’s comment (talk turn 9) provides strong linguistic evidence for how the committee assessed Gloria. He argued that Gloria “already” had experience that could “help” his department fix a problem. This is not the kind of talk that one would expect if Gloria was needy in the same way that Constance was or if the internship had a stable construction as an educational opportunity for a student.
In segment 7 below, the committee continued to build the case for selecting Gloria based not only on her qualifications but because she was perceived to fit into the department’s culture. Gloria appeared to put the two scientists at ease regarding her knowledge of computer coding and software tools.

**Segment 7 (2:15 – 3:12)**

**Scientist 2:** she seems to have a pretty good (. ) a pretty good sense of (. ) you know (. ) the different tools that are out there and how to use them which is pretty good // and

**Scientist 1:** a good // grasp of the MATLAB v Python (. ) the pros and cons of open source

**PD:** yes

**Scientist 1:** cause that's a new thing (. ) and the trick is there’s no right answer yeah // I just wanted to hear her

**PD:** yes (. ) and she hit the right things // of the GUI? (. ) the

**Scientist 1:** the convenience (. ) whatever removes your choice removes your control

**PD:** right right exactly

**Scientist 1:** I (. ) I liked it (. ) It was a thoughtful and well-considered answer

**Scientist 2:** definitely yeah (. ) and I liked her answer (. ) and (. ) and about defining the problem and iterating on the problem and (. ) you know (. ) I liked that (1.0) and I liked (. ) she seemed to really enjoy? what she did which I think is very important in the sciences ((Scientist 2 short laugh))

**Scientist 1:** yeah // yeah

**Scientist 2:** like you really you really gotta // love it in order to (. ) you know.

**Scientist 1:** yeah. It’ll really get in your head (. ) when I get home I don't stop working

**Scientist 2:** I know

**Scientist 1:** I'm still thinking about stuff

**Scientist 2:** ((Laughter)) yeah I know (. ) it's hard not to

**PD:** I wish I could ((laughter))

The committee’s discussion almost made it seem as if Gloria was a long-lost colleague.

They felt that she understood useful computer software (e.g., MATLAB) and coding languages (Python). She demonstrated niche content knowledge about open source software. She also impressed upon the committee that she had a sense of how to problem solve systematically. Lastly, the committee members spoke about how Gloria appeared excited and interested in the kind of work that she would be doing at the internship, a favorable assessment that she shared with Constance. The committee also inferred from Gloria’s interview that she would be a good
fit for the laboratory’s work culture. In short, Gloria was being positioned almost as an insider in the department.

Segment 8 below cemented the shift in how “need” was employed for Gloria compared to how it was used for Constance and Tristan on Day 1. The “she” in the beginning of this segment referred to Gloria.

Segment 8 (3:30 – 4:27)

PD: so (. ) no question (. ) she’s number one right?
Scientist 2: I would say so (. )
Scientist 1: yes
Scientist 2: I really like (. ) the double major? (1.0) // I think that (. ) that
PD: yes/
Scientist 2: it shows real (. ) I don’t know (. ) like
Scientist 1: STEAM v STEM
PD: yeah
Scientist 2: yeah (. ) like motion picture and image image science is kind of interesting
because when I read her resume originally (. ) I thought that (. ) too (. ) to me that
says like (. ) future (. ) science communicator person
Scientist 1 and PD: yes
Scientist 2: which is
PD: // I can’t wait (. ) we need her
Scientist 2: which (. ) // we need more of those in the world yeah so (. ) that that I think is (. ) a
really interesting combination I think
PD: plus? on that same note? (. ) when she talked about color (. ) like she’s taking this
color class? (1.0)
Scientist 2: sure yeah
PD: I mean she brought in (. ) a perspective that I think (. ) was almost like an artist side
of her with a (. ) illuminance and the chrome (. ) chroma (. ) chrominance was it?

This segment followed almost immediately from segment 7. It is significant in that committee members settled on Gloria as the first-place candidate. The program director made the first suggestion that Gloria be given consideration as the best candidate, which was seconded by Scientist 2. Although Scientist 1 did not agree with the other two in this moment, he never went against their decision. Later, when prompted, he suggested that Constance should be Gloria’s runner-up. The program director was the first to declare that “We need her.” This need, however,
was not the need that was used with Constance and Tristan. Note the ambiguity of the plural first-person pronoun “we” which could refer to a varying combination of the internship program, the government laboratory, the department to which Gloria applied, or even “we” in the sense that the greater society could benefit from more effective science communicators. Here, need was accompanied by impressions of Gloria’s “artist side,” her potential to be a science communicator, and her being a paragon of a STEAM candidate. These terms pointed to qualifications or merit markers.

In the Day 1 deliberations, need was attached to an internship that was constructed as a learning opportunity for a student intern. In Day 2, no obvious construction of the internship accompanies this new way need is used. What kind of internship would need Gloria? I strongly suspect the trick to understanding the new construction of the internship lies in noting how the committee members had been building a qualifications-based terministic screen around Gloria. From how the committee spoke about Gloria, it is possible to infer an implicit construction of the internship as a traditional merit competition for the best qualified candidate. On Day 1, Constance needed the internship. On Day 2, the internship needed Gloria. Focusing on the word need allows one to see clearly how the internship took on two different purposes for the department. On Day 1, Constance was the recipient of an internship opportunity. On Day 2, the internship was the recipient of Gloria, a highly qualified candidate.

In segment 9 below, the selection committee was winding down their discussion and implicitly compared Gloria to a great athlete and formally categorized Constance as a needy hire. Here, as in the Day 1 deliberations, “need” could be read as Constance needing the internship for career and life experience.

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STEAM is a variation on STEM where the “A” abbreviates the word art. It is a recent movement in STEM education to infuse science and math training with artistic sensibilities.
Segment 9 (17:05 – 18:07)

Scientist 2: I really think (. ) I think we (. ) I think we have a good decision made I think (1.0) // seems like we (. ) seems like we
PD: I think you got a slam dunk with Gloria // (. ) yeah so (1.0) and you're also hitting (. ) you're finally doing an [imagine science] internship with [Gloria’s university] (. ) that’s good (. ) I felt so bad for [another intern] last year but
Scientist 1: Well [female intern from last year] was from [Gloria’s university] wasn’t she?
PD: No [Same female intern from last year] was from (. ) [a liberal arts college]
Scientist 1 and 2: // Oh!
PD: and she was kind of chosen // because of a need (1.) because she didn’t have the opportunity to really do this kind of remote sensing type of work // so yeah and
Scientist 2: they don’t have too much of a program centered on that
Scientist 1: so I’m glad you’re taking two because one is going to hit the ball out of the park with her experience already (. ) although she’s saying I I still need the real-world experience
Scientist 1 and 2: oh yeah (. ) right (. ) um hm.
PD: but still she’s got way more experience than any other kid because of her institution (. ) but Constance strikes me more as (. ) she she could really use this
Scientist 2: Yeah (. ) I think so but she’ll probably learn a lot

Segment 9 shows the different conceptualizations of the two finalists within a single transcript segment. The program director’s two final talk turns are great examples of the comparison of the two students where she considered Gloria to be “a slam dunk” and classified Constance as someone who “could really use” the internship. This segment also revealed precedent at the government laboratory for selecting an intern based on need. The qualification distance between the two finalists was so much that by the program director’s fourth talk turn she appeared to discount Gloria’s apparent claim of “needing” the internship to gain real world work experience. Part of why the program director perceived Gloria as not needing real world experience was because of the highly applied nature of research conducted at Gloria’s university. In her second to last talk turn, the program director mentioned her satisfaction that the committee was selecting two students based on an implicit comparison of the two students. Being able to select two students enabled the committee to pick one that would be an excellent contribution to
the workplace and a second student that would gain a lot of experience. In other words, Gloria was almost sure to get her work project done while the committee would be “helping” another student.

**Summary.** Through transcript segments and analysis, I have shown that Constance and Gloria were selected for the internship for different reasons. Although neither was judged to be incapable of completing a project over the summer, Constance was selected based on need and Gloria for her qualifications. Accordingly, I was able to show that two terministic screens accompanied these two interns. Constance’s opportunity-based terministic screen focused the committee on constructing the internship as a learning opportunity and offering it to the student who could benefit the most from. Gloria’s qualifications-based terministic screen focused the committee on selecting a student for her qualifications and matching this student to an implicitly defined internship position that was more like a traditional job hire.

So far, my argument has been that by developing two conceptions of the internship and applying the selection criteria unequally across the students, the committee was able to finalize selecting Constance and Gloria over Tristan. Now I turn to the case of diversity as a selection criterion.

**The Diversity Conversation**

The only conversation about diversity occurred at the end of the Day 1 deliberation. Prior to presenting segment 10, which is the diversity dialog in its entirety, I want to provide a few important contextual contingencies. First, this was a tense conversation and the first half of the conversation reads as if the committee members felt they had dodged a legal bullet. They used language indicative of a defensive position. Second, they were debriefing their usage of the diversity mission while I was in the room recording the conversation. Regardless of how they
truly felt about the diversity mission, there was incentive to not be recorded saying anything controversial.

Segment 10 followed from a section of dialog where the program director had declared two rules or conditions for selecting candidates. The first was, for all departments participating in the internship that year, that she would only accept one student who attended a university in the same state as the government laboratory. The second rule was that students should be selected for their needs. I have already shown that this second rule was basically violated in the case of Gloria but not for Constance. The program director’s declaration of rules led to her first statement in segment 10 where she introduced the consideration for “a bit of balance” on selecting students for diversity. Balance had to do with taking into account the selection rules as they worked across the five departments at the laboratory that were choosing students. Unlike the rules for selecting students based on need and state of origin, there was no established rule for selecting students based on diversity.
Segment 10 (7:43-9:00)

PD: but I do have to have kind of a little bit of balance on some of that and same with the diversity piece and all that but that's ok (1.0) hooh ((mouthed noise)) (1.0) the the future lawyer sitting in that interview? asking that question? oh my God ((hand sound striking table)) ((all three kind of laugh))

PD: ((to Erik)) he asked us about what we do with our diversity mission

Erik: the intern did? ((PD laughs))

PD: and I'm sitting there thinking (.) who's sitting there with you, you know? Oh my God ((she makes a fake asphyxiating sound))

Scientist 1: yeah ((laughter))

Scientist 2: that was a trip

Scientist 1: did he have special counsel outside of the range of the camera off to the side there (.) you know? ((Scientist 1 laughs))

Scientist 2: yeah (.) I was dreading answering that

Scientist 1: you know (.) it was good (.) I was interested that he was interested in that (1.) and // that’s

Scientist 2: yeah //

Scientist 1: well, and that's part of it, too (.) // I mean

PD: I think he's concerned // he's going to be disqualified in a way because he's not an underrepresented [inaudible, minority?] (.)

Scientist 2: it could be (.) although he does mention that // yeah, his parents

Scientist 1: except he’s first gen //

Scientist 2: he does mention that his parents get

PD: I should have mentioned that

Scientist 1: for a lot of folks don't consider that to be (.) diversity here is pretty broad

PD: well it isn't

Scientist 1: it's not like a quota system on three attributes

PD: it's not

Scientist 1: it's less exposure or you know (.) first-generation college or what have you. (.) it’s

Scientist 2: yeah

Scientist 1: it's much more broad

PD: it's a lot of

Scientist 2: since he mentions that his parents couldn't afford to go to college (.) that does (.) that's an important factor (.) // so

PD: that's right // that's right

In broad strokes, the diversity discussion was heavily colored by legal references about Tristan’s perceived sociodemographic membership and the legality of the internship’s diversity mission (e.g., legal counsel, lawyer, quota). Tristan had asked the selection committee how they used the diversity mission and the first half of the dialog showed the committee reflecting on his question. The three committee members spoke about Tristan’s question with some worry and
Scientist 2 had even used the word “dread” to describe not wanting to answer Tristan’s question. The program director picked out what she thought was Tristan’s primary concern: that he would be eliminated as a white male because his sociodemographic group was not underrepresented in STEM fields. This was as close as the diversity conversation got to discussing race. The three examples of diverse characteristics offered in this dialog were first generation college status, low-income, and having less exposure to guided research experiences.

After the program director’s inference about Tristan’s concerns, I strongly suspect that the committee engaged in linguistic work in the service of two main objectives. The first was to continue to make sense of and arrive at some shared understanding of how the diversity mission was going to be used as a selection category. As I have shown with the case of Constance’s need, one step in constructing a selection category is to suggest acceptable rules that can be applied to the student candidates. The committee started in the direction of discussing rules for application but never finished. The program director picked out what she felt was Tristan’s primary concern: his elimination based on being a white male and therefore not a diversity candidate. In talk turn 12, the program director’s framing of Tristan’s concern can be interpreted in one of two ways. It is either a referential statement (e.g., observation of Tristan’s intentions) or a declarative statement stating that Tristan was not a diversity candidate. I suspect the latter of the interpretations based on the program director’s talk turn 19 where she denied that Tristan was a candidate who would contribute to the diversity of the summer internship’s cohort diversity, despite his first-generation status. She said, “Well it isn’t” where I understand the “it” to refer to Tristan’s status as a member of an underrepresented group. If this is right, then Tristan’s race could have effectively ruled him out as a diversity candidate.
The second objective was to place the use of the diversity mission on firm legal and ethical footing, which began after talk turn 17 (Scientist 1). They used two strategies. The first was using defensive language to highlight what the diversity mission was not. The second was affirming what the diversity mission was. The internship’s diversity mission was not a quota system based on a select few attributes. In contrast, it was constructed as “broad” and could include first generation students and students with little research exposure. The committee, and in particular Scientist 2, suggested that Tristan’s first-generation status could count as diversity or at least be “an important factor.”

What is difficult to discern from segment 10 is any kind of decision rule for the application of the diversity mission. Based on the contents of this discussion, Tristan’s first-generation status could have counted in his favor, but his racial status could have counted against him. It was also possible that Tristan and Constance could have been considered as a diverse candidate because, as a woman, she could have counted as a member of an underrepresented group in engineering or computer science while Tristan could have been considered as a first-generation college student (NSF, 2017). If the two candidates were considered equally to be diversity candidates, then there would be no obvious way to distribute any advantage based on candidate diversity. The diversity conversation seemed too haphazard, inconclusive, and brief to learn about how diversity might have mattered for the fate of these students or how diversity might have become a linguistic tool to assist in student selection. Moreover, the committee never spoke about diversity again. This conversation showed that selection committee members of STEM undergraduate research programs and internships may still struggle with applying demographic diversity as a selection criterion for hiring.
Limitations of this Study

The most salient limitation is the small sample size, which reduces the generalizability of this study. Because I claim that the individuals that make of the selection committee and how these members interpret the mission of the internships will have an influence on which kinds of students are selected, it may be the case that similar ad hoc selection committees from this same government laboratory chose undergraduate interns for different reasons. Generalizability becomes more difficult as one shifts context to different sorts of institutions.

The second limitation is that I did not observe the entire selection process. I did not observe how the applicant pool was reduced to these finalists. The earlier selection process was distinct from the finalist selection process on several fronts. First, the program director was less involved with the science mentors as they made the first cut in the applicant pool. Second, the science mentors relied mostly on information taken from the student applications, not interviews. It may be that different criteria were employed during the early selection process (e.g., minimum GPA, eliminating students with seemingly irrelevant declared majors).

Third, the two scientists and the program director comprised an ad hoc committee. These are not hiring professionals or human resource officers. While they each had some experience with hiring summer interns and worked directly with the interns, the nature of their conversation may be quite different from a group of professionals who specialize in recruiting and hiring, such as university admissions officers.

Discussion

Discourse and the Selection Process

The primary objective underlying the social practice of hiring, as opposed to recruiting, is to reduce the applicant pool to a set of finalists for a position and then pick one. In this article, I
analyzed the final stage of hiring for a STEM undergraduate internship at a government laboratory. On the accounts of the members of the selection committee, all three final candidates were deemed capable of finishing a summer internship project. That job finalists are often highly qualified makes selection committee work difficult and may, in part, transform the hiring process into a candidate elimination process.

At a descriptive level, the committee hired the two candidates through a common hiring practice of interviewing finalists and then using committee-level deliberations and application materials to discuss candidates’ relative strengths and weaknesses. The committee employed compare and contrast work where, for the most part, Tristan and Constance were compared to each other on several fronts: prior work experience, education, knowledge about the spectrometer, and need for the internship. There may have been circumstantial reasons why the compare and contrast conversational activity was contained to these two. First, they both were interviewed on Day 1 and the new interview information (i.e., beyond a reading of the applications) on which the committee could base a selection decision was limited to those two students. Second, on Day 2, Gloria had interviewed so well that Tristan and Constance were set in competition again for the remaining position.

In addition to compare and contrast work, the committee discussed the merits and human diversity of the individual undergraduate candidates. Individual-level evaluations were most clearly observed in the case of Gloria, but all three candidates received isolated scrutiny. The committee described Tristan as a “programmy guy” and Constance as a “big picture” thinker. Two of three committee members appeared to consider Tristan’s first-generation college student status as a marker of his demographic diversity. The committee spoke of Gloria as having useful background knowledge. As Laursen et al. (2010) noted in their interview study, often the
discussion of a students’ personal attributes could be positive or negative. Tristan’s dislike of mathematics was generally viewed negatively. Perceived interest and excitement from the candidate were viewed positively by the selection committee.

This study’s addition to Laursen et al.’s (2010) work was to document how committee members made these positive and negative assessments based on student attributes. Comparing individuals to each other and assessing them in isolation were insufficient tactics for hiring because they lacked a comparative anchor. For instance, Tristan had to be viewed as better or worse than Constance regarding something. Just the same, Gloria could not just be a “slam dunk” but had to be an ideal candidate in reference to something. This is where the committee’s use of selection criteria or assessment categories was essential. Selection criteria anchored the individual or comparative evaluations. To see this, consider the following grammatical structures that were common in the committee’s language where the Z terms are the comparative anchors.

For compare and contrast situations: Candidate X had more Z than candidate Y. An example statement was that Tristan (X) was considered to have more guided research experience (Z) than Constance (Y). For individual assessments: Candidate X was good or bad at Z. An example statement was that Gloria (X) had good knowledge of how sensors operate in the real world (Z).

The reason it is worth understanding the grammatical structures of these kind of statements is that the use of these and similar sentences brought the committee one step closer to making evaluations of the students. Yet, taken in isolation from the context of the larger deliberation, even the use of a comparative anchor was insufficient. This is because the Z term in both grammatical structures must be infused with an evaluative quality. For instance, Tristan may have had more guided research experience, but was that positive or negative? In terms of
being hired, was it beneficial for Gloria to understand that sensors malfunction? As my analysis showed, having knowledge of sensors might not have helped Tristan. To understand how the committee could make these more highly evaluative statements, it is important to understand how they constructed the purpose of the internship. I strongly suspect that the X, Y, and Z terms are relevant features in the context of hiring practices. In the next section, I argue that the Z terms need further evaluative context to be helpful in hiring practices. The terministic screens provided insight into this further evaluative context.

**Multiple Purposes of the Internships**

As I analyzed the cases of Constance and Tristan, the word need came to mean what a student could gain from the internship that he or she did not already have. Scientist 1 was fond of presenting the internship as an offering to the student and Scientist 2 and the program director constructed the internship as an “educational experience” for the student candidates. The work of the committee was to arrive at a rough consensus position that the internship will be distributed based on need and that the neediest student was the one with the weakest educational and work experience background. This kind of construction of the internship as a developmental opportunity for students began as early as segment 1 and continued to be built through Day 1. Phrases like “this opportunity could be useful for” and “the internship could be valuable for” and, of course, “Constance could use this” became part of the opportunity-based terministic screen that directed the committee toward selecting a candidate based on who would benefit the most from the internship.

With an internship constructed as an educational opportunity, the committee members could then infuse the Z terms in their statements with evaluative qualities. Tristan having more guided research experience was negative because Constance could learn more from the
internship than Tristan. Thus, on that particular selection criterion (i.e., having research experience) Constance’s lack of experience was an advantage. This is why I went to great lengths in the findings section to contrast Tristan’s prior experience with a merit framing: if the internship had been framed as a way to get the most amount of work out of the interns, then Tristan’s experience would have been viewed favorably. That the purpose of the internship needs to be anchored in some evaluative sense extends Laursen et al.’s (2010) examination of student selection a bit further. It is not enough to know that students are evaluated based on certain criteria and what those criteria are. Selection committee members also likely have a sense of the purpose(s) or use(s) of the internship which helps them to determine if a student is an ideal or unideal candidate. This is how the Z terms become infused with evaluative qualities.

The internship as an offering or learning opportunity was not the only construction of the internship. Gloria was never seriously assessed based on her need or capacity to grow from the experience. The committee never anchored the internship as a learning opportunity for Gloria. In fact, on several occasions committee members noted that they either “needed” Gloria for the internship, that the world “needed” more people like Gloria for science communication. The consistent references to her work experience and knowledge comprised the second, qualifications-based terministic screen. Gloria’s victory was more typical of a traditional merit selection for a competitive job position.

Two loose threads remain in this discussion. The first remaining puzzle was that the internship was constructed in two different ways and I was able to identify two distinct terministic screens. In his 1965 treatment of terministic screens, Burke suggested that certain terms direct people’s attention down certain channels or toward certain fields, by which he meant roughly that terms trigger in their minds particular mental directions. Terms are loaded with
meaning and when certain terms are employed and understood by the recipient they contain necessary implications. Following from this understanding of terministic screens, it would seem improbable that the internship could be constructed one way for Constance and Tristan and a second way for Gloria. Yet this is exactly what happened. The analytic power of terministic screens may have been overridden in Gloria’s case by contextual factors linking the selection process to a more traditional merit-based selection competition than a distribution of opportunities to needy students. That is, the needs-based construction of the internship may have been a deviation from the normal business of choosing candidates for their qualifications.

The last puzzle was that on Day 2, the internship’s qualifications construction was never made explicit unlike the opportunity-based one. Why was this so and how it was possible to select a student without a construction of the internship? I suspect that there is a clue hidden in segment 4. Scientist 2 began comparing Tristan and Constance in the following way, “And even though he's got the more directed experience with that, that might the reason to go for her.” I believe the “And even though” signaled a bit of reluctance on his behalf to select a student based on need as opposed to merit. That is, he signaled a kind of counter-intuitive assessment of Constance as a better fit for the internship even though Tristan had better qualifications. In the same segment, he continued, “That's, that's, it's tough. You want someone who's really qualified but also it's an educational thing.” In this quote, he laid bare a dilemma between selecting an intern based on qualifications and educational benefit. Laursen, Seymour, and Hunter (2012) pointed out that one of the fundamental tensions for faculty who mentor undergraduate students in research is between making advancements on their own research projects and the time required to train up undergraduate students during short, summer research experiences. I suspect the dilemma raised by the scientists in this study was the same but cloaked in different terms.
This kind of dilemma, of seeing students as either receiving a benefit or providing a benefit to the internship, is what made possible selecting both Constance and Gloria. Because this department was able to choose two students, Constance could be hired as a need-based candidate and Gloria as a qualifications-based candidate. However, if a department could selection only one student, the committee members might feel torn between a need-based or qualifications-based hire.

**Diversity as a Selection Consideration**

Posset (2016), Rivera (2012), and Laursen et al. (2010) noted the limited role that diversity played in admissions contexts. Posselt (2016) found that at its most extensive, all else equal between two candidates, being considered from an underrepresented group or adding to “diversity” might tip one candidate over another. Although reducing underrepresentation in STEM fields was one of the twin goals of the internship, there was little discussion among the committee members as to what diversity meant and how it would be employed in the hiring of the interns. Three points deserve mention.

First, the tone of the diversity conversation was largely defensive due to a few intersecting factors. Tristan had asked the committee how they used the diversity mission. Because Tristan was presumably a white student, the diversity mission as a mechanism for reducing underrepresentation in STEM fields did not favor him. The committee spoke about how they did not want to answer his probing question about the diversity mission and even suggested or joked that Tristan had legal counsel off screen during his interview. What largely followed was a discussion of how the diversity mission was broad enough to encompass Tristan because he came from a family of humble means and was a first-generation college student. This kind of conversation may have been doing the work of showing that the diversity mission was not
something legally or morally suspect. Although difficult to assess without interviewing the study participants, the other major factor that probably mattered was that I was in the room recording a sensitive conversation.

Second, in the Laursen et al. (2010) study, they found that some faculty mentors considered student groups that would benefit from research experiences the most. These student groups were often underrepresented in STEM fields. In Laursen et al.’s study, the mentors discussed giving women “a boost” in their academic trajectories by exposing them first-hand to authentic research as a profession. In other words, underrepresentation status and perceptions of which students would benefit the most from the research experiences had an association for these science mentors.

Something similar may have occurred in the current study regarding the internship’s diversity mission. Although the committee developed no decision rules for applying diversity as a selection criterion, they did suggest that diversity was “broad” and that it could include reference to first generation college status or coming from a low-income household. The committee members emphasized that the diversity mission was not a quota system based on a few student characteristics. It may be that, for this committee and possibly for other STEM professionals, that diversity as a hiring criterion is a broad category that can include a lot of factors. These factors may range as widely as distributing research or internship opportunities on race, gender, socioeconomic status, perceived most benefit to the student, and perhaps even perceived need. It may also be that diversity, in some cases, overlaps with perception of student disadvantage. The fact that diversity as a selection category may have so many possible interpretations could be highly problematic and difficult for ad hoc selection committees to troubleshoot. Tristan’s case, as a white male who was from a low-income household and was the
first in his family to attend college, is a great example of how some individuals can be considered to contribute to a diversity mission and other not. How are selection committees to select for diversity when several candidates have equally complex personal histories and demographic characteristics?

Third, without any obvious reference to gender, two women were chosen into an engineering and computer science internship. Gloria outcompeted the entire applicant pool based on her qualifications, and Constance, as an individual and not as a member of a gendered group, was admitted based on an opportunity-based construction of the internship. At no point was their gender leveraged to provide them an edge or argue for their inclusion into the internship.

Implications for Selection Processes and Research

Although this was a small-scale study there are a few implications for how to conduct hiring practices that may apply more widely than to this selection committee.

Advice for Ad Hoc Selection Committees

It may be useful for ad hoc selection committees to establish a kind of theory of justice or fairness for selecting students. Even simple theories of justice, such as applying selection criteria equally across all candidates, may help organize the selection process. In fact, I suspect this is a critical aspect of hiring and there was evidence in the transcripts that all committee members were trying to do the “right” thing by selecting a student based on her perceived need. However, they were obviously also drawn to Gloria’s strong résumé, an attraction that had nothing to do with need.

At a more general level, ad hoc selection committees may need to spend additional time clarifying the selection criteria they will use and how these selection criteria will be applied to the students. Doing this prior to the selection event is valuable because it is one less major task
that will confront the selection committee. Applying criteria fairly to students is already a
difficult enough task without having to establish or make sense of the criteria at the same time.

While ad hoc student selection committees may benefit from establishing selection
criteria prior to the select events and the ways these criteria ought to be applied to students, some
selection categories will require more thought. For example, this committee struggled with
making sense of the demographic diversity mission of the internship. While underrepresentation
status was on the minds of the program director and Tristan, the two science mentors argued that
low-income status and being a first-generation college student were admissible markers of
diversity. It is not easy to arbitrate cases like Tristan.

Lastly, selection committees and processes are sites for potential innovation and
tinkering. This government laboratory opted to decentralize student selection by allowing
departments a great deal of autonomy in selecting students. The program director was present at
each department’s deliberations and was the administrative link to the internship program. Yet,
there are other ways to design student selection. For instance, it is possible to imagine a single
selection committee comprised of variety of employees at the government laboratory who choose
a set of students for the internship. Participating departments then choose students from this pool.
Each design will carry tradeoffs, but it is valuable to become aware of different types of selection
committees and how they operate.

Considerations for Further Research

Research on undergraduate selection practices for STEM undergraduate research
programs and internships has much potential for the scholarly community. First, many of these
programs offer an opportunity to observe ad hoc committees at work. These particular task-based
committees represent special conditions for selection, such as the members not being highly
trained in student selection. Second, researching hiring practices in the STEM community has the potential to reveal values members of the science community have and feel strongly about. For instance, what are the meritocratic rules that the STEM community adheres to, how entrenched are they, and when do scientists make exceptions to the meritocratic rule? Third, it will be interesting to note the kinds of selection criteria that are easier and more difficult for selection committees to agree upon. This type of discourse research will highlight dilemmas that selection committees struggle with. Lastly, institutional factors influence how selection process and criteria vary. Are selection processes and criteria distinct for STEM internships and undergraduate research programs? Does the former value more practical experience while the latter value prior research experience?

Regarding diversity, it may be valuable to further investigate how selection committees make sense of and use diversity as a hiring criterion. These investigations may matter for funding agencies that are spending millions of dollars on broadening participation initiatives. This investigation should focus on if, how and when diversity overlaps with considerations of underrepresentation status. There may a disconnect between the institutional priorities of the NSF and NIH, which focus heavily on demographic underrepresentation, and practitioners, who use diversity as a proxy for demographic underrepresentation but also consider other diversity factors about student candidates. That is, local actors, like the people in this study, may see selecting for broadening participation as synonymous with selecting for diversity but also view selecting for diversity as not strictly synonymous with selecting for demographic underrepresentation.
Appendix

Notation Symbols Used

(.)  Short pause

(1.0) Timed pause

.  Downward intonation

?  Upward intonation

-  An interrupted talk

text  Word emphasized in
talk

((text))  Clarifying text

//  Speaking atop another
Conclusion and Future Directions
I am fortunate to have studied a small area of the social world that is both relatively unstudied and holds the potential for learning about the human condition. Every year, thousands of undergraduate research programs and internships conduct student recruitment and selection activities. Because recruitment and selection processes are driven by human values and interests, they offer windows into what people value as well as their personal notions of fairness. Some undergraduate research programs and internships have existed for decades and some are brand new. Some attempt to generate an initial motivational spark so that students want to pursue STEM degree programs and careers. Other programs operate with an explicit interest in recruiting students into graduate school. These and other dimensions of program diversity make them fascinating to study.

Fascinations aside, student recruitment and selection into STEM undergraduate research programs and internships have serious consequences. Recruitment and selection processes function as open doors or major roadblocks for students aspiring to participation. They are ways for programs to target specific kinds of students and, if the selection process is rigid enough, all but ensure the selection of certain kinds of students (e.g., older students, high achieving, students from elite universities). In this way, recruitment and selection processes are like the hands of a program that sift through the national population, rejecting some students and claiming others. Many of the major federally funded undergraduate research programs and internships aim to recruit, select, and train the future generation of STEM scholars, researchers, and workers. The U.S. federal government invests large sums of money to shape the demographic and intellectual character of the STEM workforce through these training and education programs. In the near future, the students who are currently participating in STEM undergraduate research programs and internships will become university faculty, STEM industry leaders, pioneers in the discovery
of cures to persistent illnesses, and problem solvers for the twenty-first century’s most pressing challenges. Other students, who may go on to more prosaic careers, will still have their professional careers influenced by these programs.

Regardless of whether students go on to live inventive or quieter lives, when they applied to their research experience or internships they very likely had to, first, become aware of the opportunity and, second, compete against other candidates. There are not enough of these STEM programs to meet student demand and this scarcity of opportunity (or abundance of interest) will continue to fuel scholarly interest in recruitment and selection. It will be of continual interest to observe what priorities the U.S. government places on student recruitment and selection, how these priorities are set, and how individual programs and selection committees respond to these priorities. With over 700 STEM undergraduate research programs funded in 2018 by the National Science Foundation alone, there is much territory to explore.

With this short introduction laid out, I now turn to a summary of what I have contributed to the study of student recruitment and selection in the context of undergraduate research programs and internships.

**Overview of the Main Arguments and Findings**

In the previous paragraphs, I mapped out in broad strokes the problem space and the importance of studying recruitment and selection activities for STEM undergraduate research programs and internships. The problem space is vast and the number of potential research questions just as numerous. Thus, this three-article dissertation tackled a manageable piece. As I wrote in the introduction (see figure 1), research into recruitment and selection processes can be lumped into three types: normative, empirical, and blended normative-empirical. Of the three articles in this dissertation, the first is mainly normative and the other two are empirical. Below I
summarize the principal arguments or findings of each article. I end this section with a brief sketch of four research areas that can be understood as a future research agenda.

**Article 1. A Feminist Standpoint Argument for Gender as Merit in Undergraduate Research Program Admissions**

This essay was primarily philosophical and entered into the debate around broadening participation from a feminist social epistemological perspective. Since at least the 1980s, second wave feminists of science have introduced and debated feminist standpoint theory. As social epistemologists, standpoint theorists argue that there is a significant relationship between the people who produce knowledge and the production of scientific knowledge. Standpoint theory specifically asserts that the producers of scientific knowledge leave their mark on the knowledge they produce. Social location, one’s race, socioeconomic status or historical period, strongly informs how and what one knows. Standpoints, or ways of looking at the world, are structured by group-level experiences (e.g., extreme poverty, living in segregated neighborhoods). Feminist standpoint theorists believe that the experience of gender, particularly for a woman in a patriarchal society, is one of the ways that a person can come to occupy a standpoint. Once a standpoint is occupied, it has significant epistemic benefits for the production of knowledge and, therefore, on the quality of work produced.

The main argument in this article is that selecting women into fields where they are members of underrepresented groups is justifiable and preferable to selecting more men on the grounds that women are uniquely positioned to make contributions to their respective scientific communities. The goal of strengthening scientific communities through inclusion is consistent with what has been argued in many federal reports: diversity is an asset to scientific fields. Standpoint theory is a coherent and specific account of how diversity is an asset to the
production of scientific knowledge. Gender, whenever underrepresented in STEM fields, should be considered as a marker of merit because women will contribute epistemological diversity to a field above and beyond what men can accomplish on their own. I implicate selection committees for undergraduate research programs and internships on the grounds that these early training experiences are formative for the research careers of female scientists and help to position young women to become more competitive in graduate school admissions. Scientific fields that have had historically chronic underrepresentation of women have denied themselves the epistemic benefits of inclusion.

**Article 2. Broadening Participation in the Sciences: Examining Student Recruitment Proposals for the Research Experiences for Undergraduates Program**

The National Science Foundation (NSF) has dispersed funds for the Research Experience for Undergraduates (REU) program since 1987 when it replaced another undergraduate research program. Despite its longevity and scope, the scholarly community has documented very little about its recruitment practices. Because one of the REU program’s missions is to reduce underrepresentation in scientific fields, examining the REU program’s recruitment practices should shed light on ways that similar programs can expand their outreach efforts to recruit demographically diverse students. I used two complementary data sources to learn about the diversity of student recruitment practices proposed by REU programs since 1987. The first was the record of thirteen revisions to the REU Calls for Proposals (CfPs) which are the technical grant documents that grant writers use to access REU funds. The second was eleven selected years of the REU awards abstracts. *Note:* I did not examine actual student recruitment practices but, rather, what funded REU sites proposed to do and accomplish.
An analysis of the contents of the thirteen revisions to the REU Call for Proposals (plus the original document) revealed two broad categories for student recruitment. The first were student groups consistently recommended by the NSF for recruiting since 1987. These included underrepresented minority groups (e.g., African American, Latino, American Indian), women, persons with disabilities, students not attending the REU site’s host institution, and students from universities or colleges with limited research opportunities. The second major grouping of students were those that were periodically introduced, and never eliminated, over the course of the REU program’s history. These included recommendations to recruit K-12 teachers (introduced in 1996), students pursuing associates degrees (2000), students who graduated high school but had not started college (2004), and veterans of the U.S. armed forces (2009).

Quantitative findings from the REU awards abstracts revealed that, on average, the student groups consistently mentioned in the REU CfPs comprised nearly fifty percent of the targeted student recruitment plans. Results were less conclusive regarding the student groups that were periodically included in the REU CfPs. For instance, K-12 teachers were already being proposed for recruitment prior to their formal inclusion in the grant guideline documents. U.S. veterans, on the other hand, first appeared as a targeted recruitment category after they were recommended in the REU CfPs. This mixed finding provided evidence against the notion that the only influence on student recruitment is the REU CfPs documents. The National Science foundation, while encouraging the recruitment of certain student groups, also permits the targeted recruitment of other student groups.

I extracted from the REU award abstract data the most common student recruitment strategies proposed by REU sites. The most commonly proposed strategy was recruiting students from minority serving institutions (44% of total), such as Historically Black Colleges and
Universities. The second most commonly proposed recruitment strategy was leveraging university partnerships and relationships for recruitment (26%). The third most common strategy was using organizations that specialize in broadening participation to recruit students (9%). The next most commonly used recruitment strategies were using university diversity programs (7%), traditional methods such as flyers and websites (6%), personal and professional contacts of REU staff (6%), campus visits (2%), and professional conferences (1%).

The data used in this study are limited because the bulk of the data were taken from the public REU awards abstracts which contained, at most, only a sentence or two about student recruitment. Also, the recruitment strategies and targeted demographic groups were proposals for future action and not descriptions of actual recruitment practices. This study is best framed as an exploration of student recruitment proposals that builds a foundation for future studies that will collect higher quality data supported by strong theory. Follow-up studies should investigate the successes and challenges of the proposed recruitment practices in term of anticipated goals for the student applicant pool and, also, document in more detail what these practices consisted of.

Article 3. Need, Qualifications, and Diversity: Constructing Student Selection Criteria at one Federally Funded STEM Summer Internship for Undergraduates

This study may be the first discourse analysis to examine hiring practices in the context of STEM undergraduate research programs and internships. The transcript data of two selection committee deliberation sessions provided an intimate view into how the science mentors used language to accomplish the goal of choosing candidate finalists. One of the contributions of this work is the introduction of a new methodology, discourse analysis, into the study of selection practices in STEM undergraduate research programs and internships. Previous studies had used surveys or interviews.
Consistent with other micro-sociological studies of hiring practices, the scientist mentors in this study engaged in significant linguistic work to construct meaning out of selection criteria, to apply the selection criteria to students, and to make sense of the purpose(s) of the internship. I organized the study to look at three selection criteria: need, qualifications, and demographic diversity.

**Multiple needs.** Despite the fact that the internship’s program director declared that students should be chosen based on “their needs”, the selection committee used the term need in two different ways. The first way was to identify and select a student who needed the internship for his or her development or career growth. On this interpretation of need, the committee compared two student candidates on how the internship might benefit them. The second way the committee interpreted need was aligned with a traditional qualifications assessment of the student. Committee members used it to describe how the internship needed one of the student candidates because of how highly qualified she was. The committee ceased to consider the internship as something to benefit the student but rather how the student could contribute to the workload of the department. In the end, one student was chosen for one kind of need and the second student was chosen for the other.

**Qualifications.** The committee also assessed student qualifications. Unlike other studies, I did not develop a list of qualifications against which students were compared; I focused more on social and linguistic interactions. One finding was the way student qualifications were evaluated depended on how the committee understood the purpose(s) of the internship. When the committee understood the internship as a benefit to the student, prior student work experience and research experience sometimes counted against a student. The student with fewer qualifications had an edge in this inverted competition. In contrast, when the internship was
understood as a job opportunity, the student with the strongest job qualifications was more desirable. The potentially generalizable knowledge that came from the qualifications analysis was that it is insufficient for researchers to document selection criteria when studying hiring processes. It is equally important to understand how people construct the purpose(s) of the hiring or the position. In undergraduate research programs and internships, alternative constructions of the purposes of the programs (e.g., development opportunities, to reduce underrepresentation) may lead selection committees to intentionally choose students that could benefit the most from the experience as opposed to selecting students with the strongest qualifications.

**Demographic diversity.** Reducing underrepresentation in STEM fields was one goal of the internship. However, special circumstances caused the committee to discuss diversity in legalistic and defensive terms. During his interview, one of the student finalists asked the committee how they intended to use the diversity mission to select students. In the audio recording I captured, the committee members debriefed the diversity mission but did not arrive at decision rules for how to apply it to the students. Unlike the amount of time they spent discussing the first kind of need, they had not spent enough time deliberating the diversity mission to arrive at rules for how to apply it to students. They noted what the internship’s diversity mission was not: a quota system that looked only at a few student attributes. They noted that the student who had asked the diversity mission question had qualities that could be considered diverse: he was from a low-income family and was a first-generation college student. After this short two-minute section of dialog, diversity was never mentioned again by the committee members, which meant that the students chosen for this department were chosen, as far as these data tell, without explicit reference to demographic diversity.
Perhaps the most significant takeaway from this study is the observation that the work of selection committees is highly socially contingent. The background experience, beliefs, and personal values of individual committee members influence and, stated in even stronger terms, may be partly constitutive of their student evaluations.

Future Directions for Research

The studies in this dissertation break additional ground on student recruitment and selection in the context of STEM undergraduate research programs and internship but they also raise many new questions. Below, I outline four areas of research that, based on the studies contained in this dissertation, point to promising areas of discovery.

Mapping out the Entire Selection Process

In the discourse analysis article, I emphasized that I observed only the final stage of the selection process. Although I discussed this as a limitation, it is also an opportunity. Selection processes can sometimes be long and arduous. For the government laboratory internship that I observed, roughly ninety students annually applied for five or six positions. I have read elsewhere that REU program sites can have student acceptance rates as low as six percent (Beninson, Koski, Villa, Faram & O’Connor, 2011). The first stages of student selection may be characterized by course-grained elimination of students using quantitative information such as grade point averages or age. The latter stages may require more nuanced discussions because students are more similar on the quantitative information. An interesting and useful research project is to map out the entire selection process, the selection criteria used at each stage, how these selection criteria are used, and what inferences selection committee persons make about the functional use of the criteria (e.g., students with low GPAs are unmotivated). For researchers interested in broadening participation, it might prove important to note when, and if, large
portions of the applicant pool demographic diversity are eliminated. This would be especially important if much demographic diversity in the applicant pool was eliminated during early-stage, course-grained elimination.

**The Successes and Challenges of Targeted Student Recruitment**

The article on student recruitment in the REU program focused on student recruitment proposals from individual REU sites. One general observation from the data charts is that REU sites appear interested in targeted recruitment. That is, they have in mind specific student demographic groups (e.g., Native Americans) and even locations from where they desire to recruit (tribal colleges). If REU program sites tend to have competitive admissions and want to engage in targeted recruitment, one important question is whether these sites have been successful in generating the demographic diversity in the applicant pools that they proposed and want. Have certain recruitment strategies proven effective for certain demographic groups? Have some demographic groups proven difficult to recruit from? What barriers do REU sites perceive block them from attaining their proposed recruitment goals?

Examining this question from the point of view of REU program directors and staff is one thing but it also may be valuable to consult targeted student groups to learn how they feel recruitment could be improved. Combing these two lines of research could prove generative in producing solutions to recruitment challenges.

**Student Selection and Practitioner Theories of Justice**

The discourse analysis article touched on practitioner theories of the just distribution of educational and training opportunities. One way to broadly frame the discourse analysis paper (although I chose not to) is that the committee members were attempting to understand how to distribute two internship opportunities among three students *in a fair manner*. I suspect that this
was the basic motivation behind opting to deliberate, developing an understanding of the internship’s purpose(s), and figuring out how to apply decision rules to students. Discussions of fairness pervaded many aspects of the selection committee’s discussion. Indeed, the very idea that an internship should be distributed based on any kind of need is a normative declaration. However, a second internship position was distributed to a student based on qualifications.

It would be important to understand at a deeper level what theories of just distribution of undergraduate research opportunities and internship exist within STEM communities. Is a qualifications-based meritocracy the most common view? How do practitioners feel about making meritocratic exceptions to student selection based on consideration of demographic diversity? How do STEM practitioners understand broadening participation in relation to fair selection? And, do these theories of justice have any relationship to how they act or select students?

A study like this would bridge the normative and empirical dimension of research on recruitment and selection. It would be interesting to note if practitioner views on justice roughly map onto the major philosophical positions on distributive justice. A study like this could have important implication for advocates of broadening participation if one discovered that STEM practitioners tended, on average, to be conservative, prefer meritocratic selection, and hold adverse sentiments to selecting students based on race or gender or socioeconomic class. On the other hand, it maybe that practitioners find socioeconomic status or first-generation college status more palatable than race for distributing research and internship opportunities. These are open questions.
Bridging the National Science Foundation and the National Institutes of Health

This dissertation focused entirely on STEM fields and programs funded by the National Science Foundation (NSF). Yet, other government agencies distribute funds for similar kinds of research programs and internships. The National Institutes of Health (NIH) funds and operates a summer internship for undergraduate students interested in biomedical research. Like admissions to REU program sites, admission to the NIH is highly competitive. In 2017, the acceptance rate to the NIH internship programs was around 18 percent. Many other similarities exist across the two federal agencies undergraduate research programs: emphasis on reducing underrepresentation, an interest in recruiting teachers, and a focus on community college students. To me, this suggests that anything worth researching at the NSF is worth investigating at the NIH. Research findings from both of these agencies could prove interesting, useful, and ultimately symbiotic.

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