Equity Efforts as Boundary Work: How Symbolic and Social Boundaries Shape Access and Inclusion in Graduate Education

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Background/Context: *Education scholars have examined how state policy and informal practice can widen or reproduce racial and gender inequalities in graduate education. Just one empirical study, which focused on psychology programs, has identified organizational practice that supports recruitment and retention of graduate students of color.*

Focus of Study: *To identify organizational conditions and specific activities that support diversity in STEM graduate programs, the authors conducted a yearlong case study of a physics program that, for the last decade, has trained about 10% of the Black Ph.D.s in physics, nationally. They identified and described concrete efforts to enhance access and inclusion, and sought to understand how this program distinguished itself from a traditional physics department.*

Participants: *Study participants consisted of 16 faculty, administrators, administrative staff, and students affiliated with the Applied Physics program at the University of Michigan.*

Research Design: *Data for this qualitative case study was collected through eighteen interviews, two student focus groups, observations of everyday life and special events in the program, and a large amount of documentary data. Guided by the constant comparative method, the analysis assessed convergence and divergence across types of data and across faculty, administrator, staff, and student perspectives. Major findings represent four areas of consensus across participant roles.*

Findings/Results: *Four themes explain how Applied Physics has increased access to and inclusion in a field known for its inequality. The program institutionalized a flexible, interdisciplinary intellectual paradigm; they reconceputalized their vision of the ideal student and reformed admissions accordingly; they empowered administrative staff to serve as cultural translators across racial and faculty-student boundaries; and they worked to create a family-like climate that gave them a competitive advantage over other physics programs.*

Conclusions/Recommendations: *We interpret the findings from the perspective of Charles Tilly's boundary change mechanisms, and conclude that the common thread among the four themes was the program's willingness to erase, relocate, and/or deactivate boundaries that had implicitly created barriers to access and inclusion for underrepresented students. The paper recommends specific steps that graduate programs can take to analyze the symbolic boundaries operating in their own programs, and invites scholars to utilize the boundaries perspective in future research on educational inequality.*

> The academic structures are very, very old. They're older than 200 years. They go back a thousand years. They're medieval. What we wanted was to knock down the walls. (Professor Roy Clarke, founding director of the University of Michigan applied physics program)

Graduate school is an increasingly critical part of the American opportunity structure. However, barriers to equitable enrollment by race and ethnicity persist in the form of both public policies (Garces, 2012) and informal policy and practice (Gopaul, 2012; Margolis & Romero, 1998; Milkman, Akinola, & Chugh, 2014). We see these obstacles reflected in gaps between graduate school aspirations and attainment (Mattern & Radunzel, 2015), in enrollment and attainment disparities by gender and race, especially in STEM (National Science Foundation [NSF], 2013), and in narratives of graduate students from underrepresented groups (e.g., Espino, 2014; Holley & Gardner, 2012).

A complete understanding of how inequalities at the graduate level are reproduced—and might be interrupted— must also consider the norms and assumptions that motivate informal policy and practice within graduate programs. In addition to learning their subject matter, graduate students' education includes socialization to a vast amount of tacit professional knowledge with normative dimensions, such as what types of research are important, what qualities constitute an excellent scholar, and how

scholars should relate to students and staff (Austin, 2002; Felder, 2010; Margolis & Romero, 1998). These norms include "unspoken assumptions about race and status," according to Gasman, Gerstl-Pepin, Anderson-Thompkins, Rasheed, and Hathaway (2004), which may even generate "a stormy climate for African American doctoral students and White faculty members who share values of inclusivity" (p. 690). Shifting the norms and assumptions that professors and graduate students hold could encourage deep change in the academy, because students who adopt counternormative assumptions may seed the professoriate and other professions with new ways of thinking and acting.[1] Yet, by definition, graduate programs rarely adopt counternormative priorities, practices, and relationships. We therefore have a paucity of examples of what such programs look like in practice and how they play out over time.

This assessment is consistent with the *Chronicle of Higher Education*'s 2014 Diversity in Academe report, which focused on Black male doctoral attainment in the sciences and engineering. In that report, Patton (2014) challenged scholars of graduate education to move the conversation about educational equity forward by learning from the positive examples that exist. Case study research design, in which the researcher selects and analyzes cases based on their "uniqueness, typicality, or success" (Merriam, 2009, p. 41), can facilitate learning of the sort that Patton advised.

We present an in-depth case study of the University of Michigan's (UM) applied physics program,[2] whose record is both unique and successful by the standards of the discipline. This program has trained about 10% of the Black Ph.D.s in physics nationally for the last decade, and it has received White House recognition for excellence in STEM mentoring. And although student composition does not assure equity and inclusion at all levels, this program's enrollment and graduation record for women and students of color is notable, especially given its location in a state with an affirmative action ban. In 2011, 33% of the program's Ph.D.s awarded went to students who identify as Black, Latino/a, and/or Native American versus a national average in physics of just 5% for these populations. In addition, 33% of those who enrolled and graduated were women, which is double the national average of 16% in physics.[3]

Broadly, we wanted to understand what has enabled this program to do what many others struggle to achieve. More specifically, we set out to answer two research questions: 1) To what efforts or organizational conditions do faculty, staff, and student members attribute their record of enrolling and graduating Black and Latino/a Ph.D.s? 2) How do they distinguish their program from others in physics?

To answer these questions and overcome common challenges of studying embedded organizational norms, we collected observational, interview,

and documentary data over a full academic year. Then, we inductively analyzed the data to identify key themes that faculty, staff, and student participants all discussed. Comparing across the themes, we were intrigued to see that each one corresponded to a common cultural boundary in academe or the discipline that the department worked to transcend. We therefore reinterpreted our findings using theories of social and symbolic boundaries, which explain how groups' negotiation of conceptual distinctions may institutionalize or interrupt inequalities. Through this analysis, the paper makes two contributions to the education literature. First, we offer a (largely) positive example of organizational equity efforts in graduate education. Second, our analysis invites other scholars to consider the boundaries that individuals and institutions negotiate, violate, and transcend in their efforts to improve educational access and inclusion.

LITERATURE REVIEW

Recent narrowing of racial disparities in overall graduate degree attainment is mostly due to changes in master's-level programs and in the social sciences. In STEM fields, Blacks and Latinos earned just 3–4% of the Ph.D.s in 2013, and Native American Ph.D. attainment has been not rising, but falling, over time (NSF, 2013). Absent an empirical literature about what graduate programs have done to remediate such disparities, we review research that explains inequalities, and then we infer from it possible directions for change.

THEORIZING INEQUALITY IN GRADUATE EDUCATION

In a seminal paper, Margolis and Romero (1998) used the idea of the hidden curriculum (i.e., latent, unintended learning about shared norms and values, which occurs in the course of formal learning), to explore how social inequalities were institutionalized in a graduate sociology program. Their cultural analysis illustrated that socialization into racial and gender hierarchies happens tacitly in the course of professionalization activities commonly associated with "a good education in sociology" (p. 3). Faculty conveyed the hidden curriculum in eight processes, which included stigmatizing students admitted through affirmative action and "cooling out" students' desire to study race and other applied issues (either through active discouragement and/or elevating the value of theoretical work) (pp. 12–14). Some students, however, adopted resistance strategies "to survive and transform" their learning environments (p. 25).

A small handful of studies have continued to examine processes that reproduce inequities in graduate education. Griffin and Muñiz (2011) emphasized loose coupling between the units responsible for diversifying

graduate education, especially weak coordination between recruitment efforts of Graduate Diversity Officers and admission decision making of faculty. Both Gopaul's (2012) empirical research and Ong, Wright, Espinosa, and Orfield's (2011) STEM-focused review take a Bourdieuian perspective on the reproduction of inequality in graduate education, emphasizing patterns in social capital that graduate programs value and the social capital that is developed. However, other scholars have documented limitations to Bourdieu's theory in explaining inequality in the U.S. context (Lamont, 1992) generally, and in U.S. graduate education (Posselt, 2014) specifically. And only one empirical study, which surveyed leaders from 14 graduate programs in psychology, has identified activities common to graduate programs that recruit and retain students from historically excluded backgrounds (Rogers & Molina, 2006). Whether those practices transfer to other disciplines is unclear, but Tierney and Sallee (2008) have argued that change is needed both in faculty assumptions and norms and in the structural policies and practices that they motivate. We review that literature next, focusing on physics and STEM higher education where possible.

CULTURAL FOUNDATIONS OF EDUCATIONAL PRACTICE IN STEM

Through comparative ethnographic research, Posselt (2016) found that physicists in a selective doctoral program used disciplinary norms to rationalize conventional admissions practices, such as overreliance on the GRE, which disproportionately exclude applicants from underrepresented groups. And in quantitative analyses of national data, the median GRE cutoff score of 180 physics graduate programs (700, or 166 on the new scale) excluded almost all Hispanic, Native American, and Black GRE test takers, and about 75% of those who are women (Miller, 2013; Miller & Stassun, 2014). These findings are consistent with those of a longitudinal study of physicists by Hermanowicz (2011). He concluded that their strict, narrow definitions of excellence make it difficult to satisfy disciplinary expectations for scholarship.

Professors in selective graduate programs may also rationalize narrow definitions of excellence in terms of students' perceived risk of attrition (Posselt, 2014). That rationale, however, does not hold up to evidence from an important study that women who did not complete the Ph.D. had a *higher* mean GPA than men who did not complete (Lovitts & Nelson, 2000). Despite stronger academic performance, women left doctoral programs in higher numbers than men. The problem of doctoral student attrition, they concluded, was not one of *student* ability but rather *departments'* ability to foster cultures that prioritize learning. Lovitts and Nelson

urged departments to ask themselves, "Does the department culture seem to say 'join our family' as opposed to 'do your work and leave'? Is there a productive mixture of support and competition?" (p. 46). A mixed methods study by Hurtado et al. (2011) found that a competitive culture in science courses and majors can derail STEM career interests of students from underrepresented groups, but that faculty-student relationships that balance rigor with support may foster persistence.

In physics and other education sectors with durable inequalities, encouraging equitable access and success may thus require faculty and other leaders to rethink how they evaluate and interact with students. The quality of prematriculation interactions with faculty and staff is a central factor in enrollment decisions among admitted Black, Latino/a, Native Hawaiian Pacific Islander, and Native American doctoral students (Bersola, Stolzenberg, Love, & Fosnacht, 2014). Interactions also shape mentoring relationships and feelings of validation, and are related to learning, persistence, and professional outcomes (Nora, Barlow, & Crisp, 2005; Ong et al., 2011). Bensimon and Dowd (2012) identified STEM faculty as potential institutional agents (Stanton-Salazar, 2011) in Latino student success and explained:

> It is not enough for faculty to supply students with course-based content; they must also teach students how to navigate the cultures and discourses of STEM fields, enter and interact successfully in professional STEM networks, and they must map out for them the steps necessary to pursue a career or advanced degree in one of these fields. (Bensimon & Dowd, 2012, pp. 2–3)

National leaders in physics (e.g., Kreutzer & Boudreaux, 2012) have similarly argued that efforts to improve outcomes for women and other underrepresented groups must address not only student qualifications, but also organizational cultures in physics and how they manifest in professors' knowledge and everyday practice.

THEORETICAL FRAMEWORK

We adopted cultural sociologists' conceptualization of culture as social bonding rooted in shared assumptions, norms, and logics, which actors draw upon to make meaning of their worlds and motivate behavior (Alexander, 2003). The cultural qualities of graduate programs reflect their positioning at the nexus of universities, departments, and disciplines (Clark, 1987; Golde, 2005; Gumport, 1993); therefore, to study the UM applied physics program, we followed what Trowler (2008) described as an idiographic approach to organizational culture. In contrast to nomothetic

approaches, which emphasize convergence around singular cultural logics, and inductive approaches, which are wholly open-ended, an idiographic approach to organizational culture expects to find contestation or fragmentation along common norms and assumptions (Martin, 1992). In the sections that follow, we describe common features of the disciplinary culture in physics, which the UM applied physics program might have consciously upheld or rejected. Then, we present theories of symbolic and social boundaries, and how actors may change them, in order to frame program members' equity efforts as a form of boundary work.

DISCIPLINARY CULTURE IN PHYSICS

Physics occupies a high-status position within academe and society as the oldest and most mathematically informed scientific discipline. The discipline commands respect for its intellectual intensity, financial resources (Knorr Cetina, 1999), and such iconic figures as Newton and Einstein (Hermanowicz, 2009). As a mature field of study, physics has developed strong organizational and epistemological norms. For instance, the fact that few physicists today conduct purely independent work reveals the field's reliance on collaboration (Hermanowicz, 2011). Another norm associated with the discipline's maturity is its high level of knowledge codification. Knowledge in physics is tightly packaged into a series of interconnected theoretical constructions that the majority of the disciplinary community accept (Merton & Zuckerman, 1973, as cited in Hermanowicz, 2011). Ethnographer Karin Knorr Cetina (1999) argued that theories and the means of developing and testing theories constitute physics' unique epistemic culture.

A high degree of intellectual codification necessitates a high degree of consensus, which may compel shared beliefs about other aspects of professional life, such as criteria for professional success and recognition (Hermanowicz, 2009; Posselt, 2016). Consensus and achievements in physics do not come about easily, however. To the contrary, Traweek's (1988) extended ethnography in three major physics labs convincingly portrays disciplinary advancements as the result of "elaborate and stylized combat" (p. 8) across lines of difference and disagreement.

SYMBOLIC AND SOCIAL BOUNDARIES

Cultural sociologists have argued that norms derive from the cognitive distinctions that actors make—the "fine lines" they draw— between one another and between one concept and another (Zerubavel, 1991). Social theory about boundaries emerged in response to Bourdieu's (1977) assertion that status struggle was the primary mechanism by which inequalities

are institutionalized and reproduced. Through comparative research in the U.S. and France, however, Lamont (1992) found that drawing identity-based boundaries also reproduces inequities by creating grounds for social exclusion.[4] She distinguished symbolic boundaries (i.e., conceptual distinctions, such as smart, sophisticated, or difficult to manage) from social boundaries (i.e., institutionalized social categories such as race, gender, and class). In a later theoretical paper, Lamont and Molnár (2002) explained their relationship:

> Only when symbolic boundaries are widely agreed upon can they take on a constraining character and pattern social interaction in important ways. Moreover, only then can they become social boundaries, i.e., translate, for instance, into identifiable patterns of social exclusion or class and racial segregation… But symbolic and social boundaries should be viewed as equally real: The former exist at the intersubjective level whereas the latter manifest themselves as groupings of individuals. At the causal level, symbolic boundaries can be thought of as a necessary but insufficient condition for the existence of social boundaries. (pp. 168–169)

Understanding a social group's symbolic boundaries therefore offers a powerful window into the role that facially neutral assumptions may play in inscribing social inequities.

Scholarship on social boundaries informs the current research in three specific ways. First, knowing how organizational actors define, negotiate, and perform identity-based boundaries (i.e., "boundary work") provides a glimpse into taken-for-granted cultural norms that pattern behavior (Lamont & Molnár, 2002). Second, how groups conceive of themselves and others as similar and different—and then work across the differences—is at the heart of organizational diversity work. Finally, recent theory and research on boundaries clarifies not only how they can be manipulated to institutionalize exclusion and inequity, but also how boundaries change, leading exclusive (i.e., elite or exclusionary) organizations to become more inclusive (e.g., Rao, Monin, & Durand, 2005).

Mechanisms of boundary change may, therefore, also function as mechanisms of access and inclusion. Tilly (2004) developed a typology of processes that precipitate boundary change (e.g., encounter, imposition, borrowing, conversation, and incentive shift) as well as mechanisms that constitute changing boundaries: inscription–erasure, activation–deactivation, site transfer, and relocation. *Inscription* describes how relations on either side of a salient boundary can become more sharply differentiated, while *erasure* occurs when differentiation is weakened or reversed. Next, *activation* highlights how context primes some identities and associated

boundaries to be more salient than others, while *deactivation* occurs as a particular boundary loses salience. As an example, Tilly noted how when he was writing, the boundary between his disciplinary identity and other disciplines was activated, and how his roles as teacher and father faded into the background. Under *site transfer*, the third boundary change mechanism, the existence of a boundary does not change, but actors' positioning relative to the boundary does. Examples of site transfer include racial passing and religious conversion, in which one moves across categorical racial or religious boundaries. Lastly, *relocation* combines two of the previously named mechanisms, resulting in alterations to "the major boundaries that are organizing action and interaction" (Tilly, 2004, p. 225). As we outline below, this typology provided a useful framework for understanding access and inclusion efforts as boundary work.

CASE STUDY METHODOLOGY

This paper is part of a larger, multi-institutional comparative case study aimed at understanding conditions and activities in STEM graduate programs that have maintained or increased racial or gender diversity in spite of the implementation of a state-level affirmative action ban. Case study research analyzes "bounded systems" such as organizations over a specified time period (Creswell, 2013; Merriam, 2009, p. 40). The programs we are studying each award a significantly higher share of Ph.D.s than their discipline to women or Black and Latino/a students, in light of compliance with state-level affirmative action bans. The UM applied physics program, specifically, came to our attention through administrative data, both for its success on this dimension and for a national reputation for diversity (as summarized in the introduction above and the case summary below). In the following sections, we describe and motivate the case study methods we used to study this program.

DATA COLLECTION

Case studies leverage multiple sources of data and participant perspectives to facilitate in-depth, holistic understanding of a social context (e.g., graduate program) and a phenomenon of interest (e.g., equity and diversity efforts) (Yin, 2003). For this case study, our research team collected data over 1 academic year from 16 students, faculty, and staff through interviews, focus groups, and observations of events sponsored by the program. We also reviewed a large amount of secondary data, mainly departmental documents, to put this data in context. Table 1 outlines the participants, their roles, and the types of data collected from each. We refrain from naming the race/ethnicity of our participants in order to protect their anonymity.

Table 1. Participants and Sources of Data

Name/ Pseudonym	Role	Interview Type(s)
Roy	Faculty; Founding Director	Semi-structured interview
Cagliyan	Faculty; Current Director	3 informational interviews; Semi-structured interview
Robin*	Faculty	Semi-structured interview
Steve*	Faculty; Former Administrator	Semi-structured interview
James	Faculty; Former Administrator	Semi-structured interview
Wendy*	Staff	2 informational interviews; Semi-structured interview
Amy*	Staff	2 informational interviews; Semi-structured interview
Joe*	Former Staff	Semi-structured interview
Eric*	Student	Focus group
Sarah*	Student	Focus group
Emma*	Student	Focus group; Semi-structured interview
Jamal*	Student	Focus group; Semi-structured interview
Jimmy*	Student	Focus group
Troy*	Student	Focus group
Wilson*	Student	Focus group; Semi-structured interview
Maria	Student	Focus group
Robert*	Student	Focus group

Note: *=Pseudonym

The primary sources of data analyzed for this paper included 7 unstructured informational interviews; 11 semistructured interviews; and 2 focus groups, with 4–5 students in each. Data collection began with informational interviews with the program chair and program administrative assistants. Through these conversations, we confirmed the appropriateness of the program as a case study site and identified prospective faculty, staff, and student participants through criterion sampling. Semistructured interviews with faculty, two of whom had previously served as program director, focused on the program's history, admissions practices, its response to Michigan's 2006 affirmative action ban (i.e., Proposal 2), as well as individual professors' interpretations of diversity and approaches to serving students. The faculty interviews ranged from 45–75 minutes in length.

Two 90-minute student focus groups provided insight into student experiences and perceptions of the climate for diversity and learning. We recruited focus group participants for maximal variation across cohorts, program concentrations, and racial and gender identities. We also conducted 30–60 minute semistructured interviews with three focus group participants to follow up on key themes and sensitive topics that emerged in our focus groups.

We also interviewed three former and current administrative staff members to understand their roles and efforts, which faculty and students highlighted as exceptionally important to the program's success. Interviews with administrative staff provided us with a nuanced understanding of day-to-day program activities as well as admission and recruitment practices.

All interviews and both focus groups took place in private offices or conference rooms within the program suite. We audio recorded and transcribed them verbatim. Throughout the data collection process, members of the research team generated reflective memos, which were also included in our corpus of data. Full details of our observational and secondary data collection methods are available from the authors.

DATA ANALYSIS

In answering our research questions, we designed a data analysis process that would assess convergence and divergence across faculty, student, and staff perspectives on the program's record with students of color. We opted to use the constant comparative method, a frequently used approach to analysis of case study data. The analytic process began with open and axial coding of researcher memos and the verbatim transcripts of focus groups and interviews (Corbin & Strauss, 2008).

Using NVivo 10.0.3, we first analyzed faculty and staff interview transcripts, inductively identifying key themes, codes, and patterns in the program's approaches to selecting, recruiting, and serving students. Following the same process, we then analyzed data from student focus groups and interviews. Finally, we compared faculty, staff, and student data. This between-group analysis was essential to our analytic strategy, because it allowed us to uncover shared explanations for the program's positive outcomes and areas of inconsistency based on faculty, staff, and student perspectives. These three rounds of analysis generated the four themes that anchor our findings.

Following this inductive analysis, we turned to theories of symbolic and social boundaries as a conceptual apparatus that links the major themes and roots them in patterns that social researchers have found when investigating Inequity–Equity and Exclusion–Inclusion (Pasque, Carducci,

Kuntz, & Gildersleeve, 2012). We reanalyzed our findings from a boundaries perspective and found it especially useful with respect to our second research question, which focused on how actors distinguished their program from traditional physics graduate programs.

TRUSTWORTHINESS AND RELIABILITY

Our team engaged in several strategies to increase the findings' trustworthiness and reliability, including triangulation, member checking, multiple modes of data collection, and a compositionally diverse research team. Examples of our triangulation efforts include using multiple sources of data, multiple methods of data collection, multiple investigators, and member checking (Merriam, 2009). Triangulating multiple sources of data also allowed for crosschecking and comparison of findings. Our varied interview formats—informational, semistructured, and focus groups—provided different perspectives from which to develop findings. We discussed preliminary findings in follow-up interviews with select participants, and used secondary data (e.g., recruitment materials and departmental reports) to help confirm and disconfirm early interpretations of the interviews. To increase the trustworthiness of the data, all four members of our research team were involved at various stages. As a final reliability measure, we shared a draft of the case with the current program director for feedback.

LIMITATIONS

There are two limitations to consider in the design of this study. First, we focused on an academic program with a strong history of diversity efforts, but the individuals interviewed were less racially diverse than the overall department's students and faculty. Only 3 of the 16 participants identified as Black, Latino/a, and/or Native American. Thus, these data may represent a more rosy perspective than would have been obtained with a random sample. Secondly, although our theories of organizational culture and social boundaries help explain dynamics of inclusion and exclusion, they do not clarify the how racial boundaries specifically operate. Harper (2012) argued that the study of inequity in higher education demands frameworks that center race and racism; therefore, in future study of boundary processes, educational access, and inclusion, theory that centers race may add valuable perspective.

PROGRAM DESCRIPTION AND HISTORY

The UM applied physics (AP) program enrolls about 80 doctoral students and boasts a 77% Ph.D. completion rate, which far exceeds the national average for both physics and engineering. To date, 53 Black, Latino/a, or Native American students have entered the program. Of these, 23 have graduated with a Ph.D., 20 are currently enrolled, 7 graduated with a master's degree as part of a program described below, and 3 of them left without a degree. The average time to degree for minority students (5.8 years) is shorter than the national average in physics (Mulvey & Nicholson, 2008). AP has been so successful with these important graduate school outcomes that several institutions have replicated their model.

Physicist and professor Roy Clarke[5] founded the AP program in response to cultural norms he perceived within the field of physics and within UM. He was struck by the lack of support for students pursuing innovative research outside the traditional disciplinary core as well as an institutional culture that he described as "remote" and "uncaring." To correct these conditions and their potential effects on student access, persistence, and satisfaction, Roy envisioned an interdisciplinary program that would offer a "small community within a big community," encourage collaboration, and emphasize "intellectual and social diversity." He wanted to "knock down the walls" between disciplines, departments, and people that he considered to be a holdover from the modern university's medieval origins— and which he hypothesized were a source of continuing racial and gender inequities in physical sciences.

Social, financial, and organizational factors converged to bring about the establishment of this program in the late 1980s. A state grant provided seed money, and the university president at the time, James Duderstadt, was an applied physicist himself. He saw the creation of an AP program as a strategic opportunity to: 1) bridge the geographically separate Central (liberal arts) and North (engineering) campuses, and 2) build support in STEM for the Michigan Mandate. Sparked by student protests, the Michigan Mandate is acknowledged as "one of the most comprehensive diversity initiatives ever undertaken by a predominantly White research university" (Roach, 2006, para. 1). It resulted in UM doubling its minority student enrollment over 15 years and significantly increasing the number of faculty of color (Roach, 2006). The initiative also encouraged norms around interdisciplinarity, academic excellence, and racial diversity that gave legitimacy to the innovative AP program.[6]

In time, the AP program also established a master's–Ph.D. bridge program, as we describe in the findings below, procured federal grant support for the program and select students, saw other students win NSF

fellowships, and garnered numerous recognitions for their diversity work. One could interpret the convergence of forces that supported this program's establishment as an accident of history. However, the replication of their program model and its bridge program elsewhere at the UM and across the country suggests another story: that the problem of inequality in STEM is widely known and scholars are hungry for possible solutions.

MAJOR THEMES

In this section we summarize the four major themes to which faculty, student, and staff participants all pointed in explaining AP's success enrolling and graduating women and students of color. They reflect areas of conscious effort by program members to distinguish themselves from a typical graduate program in physics. After summarizing these themes, we offer a deeper analysis in the Discussion section using Tilly's (2004) boundary change mechanisms.

INSTITUTIONALIZING A FLEXIBLE, INTERDISCIPLINARY INTELLECTUAL PARADIGM

Two features of the intellectual paradigm in AP distinguished the program from traditional physics departments and helped them attract underrepresented students: an emphasis on cross-disciplinary collaborations and the application of physics knowledge to real-world problems. From the start, program founders defined working across disciplinary boundaries as normative for their students. They developed connections with units on campus including engineering, environmental science, medicine, social work, and more. A prior director recalled how AP's development as a field has also pushed other disciplines' boundaries, with engineers now routinely using quantum mechanics, for example. Transcending disciplinary boundaries has forged novel collaborations, transformed scientific practices, resulted in significant inventions, and reshaped the doctoral education experience.

One of the program founders' central goals was reducing barriers to collaboration, but they observed that departments often operated as both intellectual and organizational silos. Therefore, when establishing themselves on campus, they opted for a "loose programmatic structure rather than formal departmental status." In this respect and others, the program was unconventional by design. They developed flexible curricular arrangements that, today, afford students the opportunities to develop an individualized course of learning with 130 faculty in over a dozen departments. In a faculty member's words, this structure draws students in with "wider options" and "a flexible means of exploring and expanding core knowledge" of physics.

Also, whereas physicists' communication and scientific practices traditionally place high value on the production of theory (Knorr Cetina, 1999), AP faculty have been more enamored with the possibilities inherent in the application of physical knowledge. Across the country, AP programs diverge from traditional ones by linking physics, knowledge from other fields, and real-world problems. As a former program director put it, "The great power of physics is it can be used to solve problems, to develop new technologies, to understand complicated interactions." They saw the program as a site of "connections between physics and other places where physics is used" and felt that this structure enabled students to develop with "more freedom."

Faculty, staff, and students alike attributed the program's ability to attract women and students of color, in part, to its intellectual focus. Faculty discussed that the "flexibility and individualization" afforded by the program's interdisciplinary orientation has been "a big selling point" for women, Black, and Latino/a students. They shared with us the common refrain they heard from prospective students: "I want to make a difference in the world. I want to be able to find a job. I don't want to go into theoretical physics because it is too disconnected from the real world." By making it easy for students to fulfill their "desire to help with societal problems," a professor noted, they made it "much easier to recruit minorities." These findings are consistent with recent evidence in the sociology of science that suggests scientists may advocate for emerging interdisciplinary intellectual fields by framing monodisciplinary work as insular and insufficiently civic-minded (Frickel, 2004). Over time, as the program institutionalized this intellectual paradigm, it came to affect not only the profile of the applicants they attracted, but also those they admitted.

RETHINKING THE "BEST STUDENTS" AND REINVENTING
ADMISSIONS

As cohorts of students progressed through the program, faculty and other leaders observed a record of success among students whose profiles differed markedly from the conventional achievers privileged in graduate admissions (Posselt, 2016). This recognition helped broaden faculty members' conception of the ideal applicant's profile.

Yet from the beginning, the program had employed "more flexible admissions criteria than comparable physics departments." Staff corroborated faculty claims that they "downplayed the standardized tests" and "jettisoned the Physics GRE." Instead, faculty closely "looked at the transcripts and…the research experience of students," as well as their fit with the program's multidisciplinary focus. We quote the current director at length:

We brought in the best students we could find. Now these are not like the typical definition of the best student that… did their undergrad degree in Harvard or Princeton or Yale, and they had a 4.0 or 3.99 GPA, and they had GRE scores up the wazoo. That wasn't kind of what we were after. We were after people who would be willing to take a big risk. They hadn't necessarily got the best grades because people who take risks when they're undergrads very often don't have stellar GPAs. They're usually very solid, but they may have taken a really difficult course because they wanted to learn about that topic, but then they only got a B-plus instead of an A. So we wanted to look for those kinds of people who were intellectually adventurous, were willing to learn about other disciplines, and willing to integrate themselves.

In these comments, we see important points about what it meant for the program to redefine "the best students." Namely, it involved clear understanding of the program's identity, willingness to question the value attributed to traditional credentials, and open-mindedness to reasons why capable students may not receive top grades.

In building cohorts of "intellectually adventurous students," program leaders have worked hard to build and sustain a critical mass who identify as women, Black, and Latino/a. They have done so both for "social justice reasons" and for "the health of the field," given AP's emphasis on innovative technologies and problem solving. They have also revisited their multifaceted recruitment plan every year. Especially since the passage of Proposal 2—the state of Michigan's affirmative action ban — this plan has included cultivating relationships with affinity groups in physical sciences and engineering (e.g., National Society of Black Engineers, Society of Hispanic Physicists) and traveling to minority serving institutions (MSIs). The program director developed a tradition of visiting at least one new MSI each fall to catalyze outreach and another MSI with which the program has an established connection.

Program leaders also made visible a commitment to reinventing doctoral admissions by establishing a research-based master's–Ph.D. bridge program for underrepresented students, inspired by the Fisk-Vanderbilt bridge program. Admitted students with nontraditional academic trajectories join a master's degree cohort and, over one year, receive financial support, research experience, credit-bearing courses, and mentoring. These activities are intended to build what one professor called students' "scientific foundation," recognizing that some applicants with strong potential benefit from time to focus their interest or build academic preparation before embarking on the Ph.D. We heard murmurs among a few

students and program-affiliated faculty that the bridge program runs the risk of creating a "second-class citizenry"—and we return to this question below—but leaders and student participants alike remain firmly persuaded of the net benefits. They point both to their own success and to the spread of similar programs in other departments at UM and around the country as evidence of its value.

Within the Ph.D. program, program leaders contrasted their philosophy of holistic review and individualized support with the "stylized combat" (Traweek, 1988, p. 8) typical in the sciences. Roy reflected, "We made it clear that people who come here succeed. So it is not hand-to-hand combat. The weeder system is where you look to your right and to your left; one of you is going to be gone. That was not us. We've always had very high success rates." Each professor expressed, in some way, that AP's unusual success enrolling women and students of color was tied to both purposeful reevaluation of "the best students" and focused investment in recruiting students who might grow to reflect their ideal.

ADMINISTRATIVE STAFF AS AGENTS OF CULTURAL TRANSLATION
AND FACULTY LEARNING

Reading to this point, it may seem that the founding faculty, directors, and students themselves deserve primary credit for the program's success. However, the story would be incomplete without discussing the counternormative work and roles of their administrative support staff. Administrative staff typically have limited authority within academic departments and are often invisible in higher education research as well. However, two staff members in this program, Wendy and Joe, played instrumental roles as cultural translators and agents of faculty learning and student support.

For depth, we focus on Joe, whom every single participant mentioned as important to the program's success with underrepresented students. Joe is a gregarious Black man, a first-generation graduate of UM, and a popular local DJ. When he was hired as a full-time program assistant after working with the program in a work-study capacity, he was younger than most of the students the program was admitting, "You know I was in my early 20s. I was like everybody else. I had the chains. I had the big earring…I was wearing jeans and a t-shirt…" Though Joe assumed that he should change his appearance for this full-time position, Roy was adamant that he be himself: "I don't want anything about you to change. You stay who you are. That's why I want you in this position." Joe recalled that Roy had a "vision" for his role that stemmed from the almost effortless way he connected with students of different backgrounds.

Joe's job was to provide administrative support and record keeping for admissions and recruitment activities, but program leaders became aware of what one called his "way with students." His responsibilities and influence quickly exceeded his formal position. Shortly after transitioning to his full-time position he began traveling with the program director to recruit students from MSIs and providing holistic support to students after matriculation. Joe became a go-to person for both faculty and students, and served as an intermediary between the two parties. A professor admiringly said of him,

> There are many things students will not tell the director…because you don't want to tell the director, "I'm not doing well in this school."… But Joe was the eyes and ears of the program; he was the contact with *all* students. He will be able to tell you aspects of the program that no one else will be able to tell you.

As the program's "eyes and ears," Joe was entrusted by faculty to monitor students, particularly those exhibiting fluctuations in behavior and/or academic performance. Joe explained it this way: "Even if I missed it, [faculty] would say, 'Well, can you find out what's going on?' And then lo and behold—I would be able to find those things out. And they would say, 'Well, I knew it.'"

The trust he engendered, paired with his ease working across racial and professional role boundaries, enabled Joe to serve as a cultural translator. He informally facilitated faculty learning, providing perspective that developed their capacity to effectively serve Black students. With most of the faculty members White[7] and a growing fraction of the student population Black, the importance of his work in helping faculty "get it" with respect to advising across race cannot be overstated. A former director acknowledged Joe as "my pipeline to the students and particularly African American students." As just one of several examples, his identities and experiences as a Black male at the university enabled him to shift how a program director, Cagliyan, interpreted a Black student's performance. Cagliyan relayed:

> With African American students, he [Joe] would have certain things that I wouldn't get… There was a student who was struggling, and he would explain to me that this was a student who would never ask for help: "You don't understand. This is not how an African American male would act. He would just never do it." So it was an issue, because I wasn't getting it. The student would get a task and didn't complete the task and it doesn't look good and I could explain to the student that it's OK to say "I don't know or I didn't understand." Having that type of knowledge, which I don't have, is really really valuable.

Joe also volunteered that students would occasionally come to him, upset about difficult patterns of interaction with faculty outside the AP core. He shared with us how he approached the program director in these situations:

> I had some real heart-to-hearts with Professor Cagliyan in the first year… He didn't quite understand. I would just go in his office and close the door and talk to him. I would tell him, "You know as much as I know that you care about students. I don't quite think you're getting it."…. And at the end of the day he would tell me, "Thank you."

Sarah, a White doctoral student, told us about an experience of feeling pushed out of her lab and unsure whether she could trust the advice she had received:

> Joe, bless his heart, came through for me. And he was like, "No-no. You should have come to me first and told me you were going to work for that guy and I would have told you, no"…. It was clear it was going to be a bad situation and Joe—he got me out of that.

We could fill pages with examples of Joe's supportive advocacy. Students depicted him as "really serious about having your back" and providing support for "serious departmental political-type problems." When we asked Joe to describe a highlight of his experience with the program, he relayed a story involving a Black male student:

> When it came time to take his quals, he didn't do well… He came down to my office and the look on his face… "They're telling me I have to leave the program. I can't get my Ph.D. from the University of Michigan." And that was his dream…I calmed him down. I said, "Come back in a half hour; I got you." I walked right into the professor's office and told him, "…I know this kid wants it." Long story short, he has a Ph.D. in applied physics… He's been teaching, he's doing great things.

Students saw him as trustworthy and capable of bringing resolution to concerns, especially amid perceptions of unfairness or inequity. Joe was emphatic that the program cared about creating an inclusive environment, commenting, "[T]hey just didn't just talk the talk; they walked the walk." Yet he also noted that maintaining this environment did not always come naturally for program leaders. For his ability to build bridges across racial and role divides within the program, he knew, and others affirmed, what an asset he was.

Over time, he came to play an advisory role. Joe was tapped for insight when program leaders sought to understand declining student of color

enrollment, and he discussed potential changes in AP directorship with the graduate school dean. Such involvement highlights his credibility and leadership, but also raises questions about whether he was rewarded with positional authority commensurate with his contributions. When Roy and the AP program received an award from the Obama administration for their commitment to diversity and mentoring, however, Joe was the colleague whom Roy invited to join him at the White House. In an emotional moment of our interview, Joe shared, "I can't even tell you what that felt like… I guess that goes to show you how much I meant to him and the program." President Obama's recognition was a point of pride for everyone in the program, and a large framed photo and certificate marking the event hung in the main office—directly above Joe's desk.

ATTRACTING AND SUPPORTING STUDENTS WITH A FAMILY-LIKE COMMUNITY

Finally, the AP program encouraged inclusion by extending themselves to create a community that differed markedly from the "remote" and "uncaring" relationships that the program founder had seen elsewhere in physics. When we asked the current program director to explain what he does to encourage the success of underrepresented students, he said, "Maybe more than *any*thing else from Day One, we tried to institute an atmosphere which was what I call 'like a family.'" Admittedly, as members of the research team, we were initially a bit skeptical about how "the family" metaphor played out in reality. Over our year with the program, however, we came to see that staff, core faculty, and students all worked hard to make the family metaphor a lived experience. Nearly every single student mentioned the "family" as important to their educational experience, and we observed program administrators at all levels going above and beyond what was expected and necessary—driving 3 hours to attend a parent's funeral, for example.

Program staff and core faculty consciously used the family metaphor with prospective students because they knew it distinguished them from the typical physics department. It was a strategic move, in fact, with one director describing "the family" as a "competitive advantage." With the exception of one student, focus group participants indicated that the family-like culture was central to the program's recruitment narrative and their own decisions to enroll. William noticed it right away. "The thing I noticed the most was that it was a much warmer environment than other schools that I had applied to… When you come in, the administrators say, 'Welcome to the family.' And it seems like they've said that years and years in a row." Emma and Jamal also recounted their campus visits:

> *Emma:* The day I visited, they kept saying things like, "Applied Physics is like a family." I didn't know what that meant, but I heard it a lot…. And I didn't know about the diversity when I applied.
>
> *Jamal:* Everyone I talked to in the program kept saying, "It is a family."… I wasn't sure what that meant exactly, but everyone said that. And it was a smaller group and I felt I would be supported and cared for well.

Students added such language as "comfortable," "supportive," "cohesive," and "energetic" when describing the program's environment.

Recognizing that many academic programs strive to convey collegiality when they are in recruitment mode, a focus group facilitator probed participants to describe "an experience that made you feel this really is a family…[that] it is not just a tagline." Brad recalled his campus visit, which had been set up separately from the usual campus visit day. Experiencing how faculty and staff went above and beyond typical roles and work hours to ensure he had a positive visit "was the experience for me that was like, 'These guys put their money where their mouth is.'" Emma reported a similar experience, and Robert added, "The first time I'd actually spoken to anyone from the university was Wendy. When I talked to her I was like, 'This is the place.'"

The "mother figure" and "big brother" roles that students attributed to Wendy and Joe reflected the program's desire for family-like relationships. "Wendy and the others work wonders over there," as one student put it. In addition to walking students through politically fraught advising situations, Joe provided direct student support. He helped attenuate their anxiety and stress, talked them through personal crises, joined them and their parents for dinner, and even stood up in student weddings. And Wendy, understanding women's unique experiences and needs, often hosted dinners—which she called "girls night out"—for women doctoral students to "talk" and "just go and hang out." Joe commented that together, he and Wendy "tried to do a lot to foster a place where they [students] really are comfortable."

That the quality of relationships affects student well-being is hardly a surprise, but this program's collective, conscious attention to relationships must not be overlooked. Many STEM graduate programs find themselves stuck in a negative feedback loop, in which poor representation of women and students of color raises red flags for prospective students about departmental climate and the quality of day-to-day life. It can deter those students from matriculating, which perpetuates isolation and tokenism. AP has interrupted this cycle by thinking strategically about climate and working hard to create a community that gives them a competitive edge

over other graduate programs. Student respondents indicated that it was a major draw to discover the diverse, warm relationships that so many in the program tried to encourage. Perhaps the strongest evidence of student satisfaction was their pride in playing a recruiting role themselves, welcoming prospective students into "the family."

EQUITY EFFORTS AS BOUNDARY WORK

Before discussing implications and directions for future research, we interpret the four primary themes more explicitly as a matter of boundary change, drawing from Tilly's (2004) mechanisms: erasure–inscription, activation–deactivation, site transfer, and relocation. Through this analysis, we illustrate how the program's efforts to improve Black and Latino/a students' access to and inclusion in physics graduate education fundamentally altered traditional intellectual, organizational, social, and professional boundaries. By doing so, we hope to make clear that 1) boundaries are not "given facts" but subtle "products of action" (White, 1992, p. 127), and 2) the negotiation of these boundaries has real implications for individual and organizational behavior. Table 2 represents the relationships we discuss in this section.

Table 2. Equity Efforts as Boundary Change

Boundary Types	Domains of Faculty & Staff Work Affected	Specific Equity, Access & Inclusion Efforts	Boundary Change Mechanisms
Intellectual Identity	Student Recruitment, Training, & Mentoring	Focus on interdisciplinarity	Partial *erasure* of a boundary between physics & other disciplines
		Focus on application of physics knowledge to real-world problems	*Inscribe* a boundary between traditional & applied physics
Organizational Membership	Recruitment & Admission	Redefine the best or ideal students	1. *Deactivate* a boundary between applicants earning top GRE scores & everyone else
			2. *Inscribe* a boundary between "risk averse" & "intellectually adventurous" students
			3. Together, 1 & 2 *relocate* the boundary on what and whom merit admission

Boundary Types	Domains of Faculty & Staff Work Affected	Specific Equity, Access & Inclusion Efforts	Boundary Change Mechanisms
Professional Roles	Delegation of work & supervision of administrative staff	Empowered staff to serve as institutional agents	Partial *erasure* of status distinctions/hierarchy between staff & faculty
	Learn to better serve underrepresented students	Cultural translation	*Activated* racial boundaries for more effective teaching & learning across them.
Interpersonal Relationships	Developing the climate for diversity & learning	Create trusting relationships & a supportive environment, akin to family	1. *Inscribe* the boundary between climate & relationships in applied physics vs. typical physics departments
			2. *Deactivated* staff-student and faculty-student boundaries to facilitate student well-being

MANIPULATING DISCIPLINARY BOUNDARIES

One of the most prominent conditions encouraging access and inclusion in the AP program was its intellectual identity as an interdisciplinary, applied area of study. This identity served as a backbone to which they deferred in making decisions, provided flexibility for faculty and students to pursue innovative research, and produced two distinct, but related, boundaries. First, the interdisciplinary nature of the program represents the partial erasure (Tilly, 2004) of a cultural boundary that separates physics from other disciplines. Professors prided themselves on collaborations through which students could appreciate the relevance of physics knowledge outside the discipline. Interestingly, by blurring this cultural boundary, faculty inscribed a distinction between applied and traditional physics. They repeatedly emphasized to prospective students the incredible potential of physical knowledge to solve real-world problems, particularly through cross-disciplinary collaborations, relative to a vision of physics that privileged theory.

Efforts to recruit underrepresented students were relevant to both of these boundaries. When underrepresented students described commitments to "making a difference," finding employment, and staying connected to the real world, it resonated strongly with both 1) the partial erasure of the physics versus other disciplines boundary, and 2) the presence of a real distinction between applied versus traditional physics. This sentiment deactivated, or made less salient, the physics–other boundary, because interdisciplinarity provided grounds for exploring how physics

might fit into their vision for social change. Simultaneously, however, students' sentiment activated the applied–traditional boundary by casting traditional physicists' focus on theory as disconnected from real-world problems.

MANIPULATING ORGANIZATIONAL BOUNDARIES BY RETHINKING MERIT

The mental models that faculty members hold about their fields of study inform approaches to gatekeeping practices, such as admissions and hiring (Lamont, 2009; Posselt, 2016). Such activities are *ipso facto* a form of organizational boundary work, and the evaluations used to determine membership reveal symbolic boundaries about what it means to be desirable, capable, intelligent—to belong. Often tacitly, these evaluations force leaders to ask normative questions: On what grounds *should* one have an opportunity to relocate from outsider to insider? What signals will define a prospective member as a "*good fit*"?

AP worked assiduously to counter prevailing schemas about "merit" that undercut admission of students from underrepresented backgrounds. Admission to most physics doctoral programs depends upon deep training in the discipline and quantitative methods used to bring about theoretical advancements. Under that model, extremely high GRE scores are interpreted as a sign that students' quantitative skills extend beyond those covered by the test. In contrast, AP's flexible intellectual paradigm, paired with its strong commitment to building social diversity in physics, motivated them to redefine who "the best students" are.[8]

In defining their vision of the ideal student, applied physicists deactivated the boundary separating those scoring in the top percentiles of the GRE physics and quantitative sections from everyone else, marshaling evidence that test scores could not predict who might grow to become a successful scholar. Simultaneously, by examining transcripts and records of research experience, faculty inscribed a boundary separating applicants who were "risk averse" from the "intellectually adventurous." These two processes—deactivating the distinction between those who earn very high GRE scores and everyone else and inscribing a boundary between the intellectually adventurous and risk averse—relocated the boundaries related to merit for admission.

MANIPULATING THE BOUNDARIES OF PROGRAM ROLES AND
RELATIONSHIPS

Our findings about the important role of program administrative staff sug-
gest that AP violated professional boundaries concerning who should have
status and authority in academe and on what basis. Lamont and Molnár
(2002) argued:

> The notion of boundaries is crucial for analyzing how social actors
> construct groups as similar and different and how it shapes their
> understanding of their responsibilities toward such groups… We
> need to focus especially on hidden assumptions concerning the
> measuring sticks used by higher and lower status groups. (p. 188)

Whereas the norm in academia is for students and administrative sup-
port staff to have subordinated status and minimal influence, the AP pro-
gram constructed these members as vital players. Everyone participated
in recruitment, and staff were key institutional agents, advocating for stu-
dents when communication with professors faltered.

Joe's title indicates that he was responsible for record keeping and re-
cruitment, but his authority was much greater. Joe does not have an M.S.
or Ph.D. He is young, Black, and technically occupied the lowest position
in the department. With traditional boundaries in place, we would ex-
pect significant cultural distance between Joe, the faculty, and program
directors. We might also expect directors, in occupying a more privileged
position in the department, to inscribe these boundaries (and their own
status) by distinguishing themselves from Joe. Instead, directors strove to
minimize the hierarchy implied by their official roles, encouraging egali-
tarian relationships and welcoming opportunity to learn how to better
serve Black students.

Joe mentioned his racial identity when talking about his shift from a
part-time to full-time position, but the activation of a racial boundary was
most explicit in Joe's role as a cultural translator and advocate for Black
students. A former director's comments that Joe was the "eyes and ears"
of the program and "my pipeline to the students and particularly African
American students" evocatively convey Joe's ability to connect across social
boundaries that separated faculty and students. Interestingly, when con-
cerned with falling enrollments, microaggressive behavior targeting Black
students, and Black students' difficulties with faculty, Joe initiated con-
versations with the program director—voluntarily activating racial bound-
aries. Absent his willingness to do so, some cross-racial faculty–student
relationships would surely have been more strained and some graduate
students would likely have fallen through the cracks. Graduate programs

that are striving to diversify would benefit from having someone who serves the role of cultural translator, but they should also work toward an organizational culture in which all faculty possess skill and commitment to support students from diverse backgrounds.

Finally, weakening the typical role-based hierarchy and empowering staff to serve as agents of faculty learning and student support opened the possibility of warm, family-like relationships that set the program apart from counterparts in other institutions' physics departments. The supportive environment and trust fostered through "the family" allowed faculty, staff, and students to break down fronts and interact as human beings (Lamont, 1992, p. 10). As "mother" and "big brother," Wendy and Joe developed relationships with all students and created a community of support that extended well beyond staff–student relationships normative in academe. They both emphasized aspects of their identities to create community within the program. Wendy stressed her shared gender identity with women students through "girls night out" and similar activities; Joe emphasized a shared identity with all students through his experience as a student at UM and his shared racial identity with Black students. Both effectively deactivated the staff–student boundary in order to connect in a way that students discussed as integral to their well-being and success.

DISCONFIRMING EVIDENCE: "HERDING CATS"

Our project goal was to understand how AP has been able to sustain and graduate a diverse student body without affirmative action; however, a search for disconfirming evidence also turned up challenges they have faced in reaching and serving students of color. Faculty reported that the university's compliance with Proposal 2 has complicated their ability to recruit underrepresented students with generous funding packages and contributed to falling enrollments of Black students. A few students shared that, despite the warm relationships in AP, it can be difficult to ignore the negative *campus* racial climate. Other students mentioned that they would like to see more direct, honest conversation about the realities of race in science.

And although the AP program has catalyzed change in some parts of the university's STEM community, they have struggled to institutionalize their priorities and practices in others. They had hoped that by operating as an interdepartmental program rather than a freestanding department that their values would seep across the boundaries of the departments with which its faculty associate. This logic aligns with Karl Weick's (1976) conception of universities as loosely coupled systems, in which weak network ties across units produce a tendency toward stasis. In loosely

coupled systems, change can occur as influential individuals (e.g., the AP program's core faculty) work at the interface of multiple networks and press colleagues in one network to learn from the culture of another. Yet one program director admitted that it has been difficult for core AP faculty to galvanize support among the program's 130 *total* faculty affiliates for norms and practices related to racial and gender equity. Comparing the challenge of building faculty consensus to "herding cats," a program director noted that his limited ability to shape faculty hiring restricted his ability to fully manifest the sort of learning community and student experience he envisioned. Though it may be impossible for any leader to prevent all negative faculty–student interactions, any student reports of feeling "like a second-class citizen" in a program that prides itself on equitably serving diverse students indicates room for growth. Effort and capacity to "herd cats" will undoubtedly shape the possibilities of expanding their influence.

In the meantime, their impressive enrollment and completion statistics have generated national attention; program directors are recognized leaders in the national movement to increase diversity and equity in physics. Cagliyan, for example, was a panelist on the topic of "Sustaining Institutional Change" at a 2015 American Physics Society meeting, and a physics magazine recently wrote a long profile about Roy's contributions. With other well-regarded graduate programs in the physical sciences having adopted their model, program leadership now confront competition in attracting prospective students.

DISCUSSION

We set out to learn from a program that is a true outlier in physics for the high proportion of its Ph.D.s awarded to women, Black, and Latino/a students. Its success with Black students has been especially notable, with the program claiming to produce about 10% of the Ph.D.s awarded in physics nationally over the last 10 years. How have they accomplished this, and what might other graduate programs learn from their example? Our assumptions upon beginning the study were that in-depth, qualitative research can reveal norms that have become so engrained that they are invisible to insiders, but which are important for understanding organizational performance and member satisfaction. Through inductive analysis, we identified four themes that faculty, students, and staff all discussed as relevant to their record of success. The program's flexible intellectual paradigm privileges the application of disciplinary knowledge to critical social problems. Directors and core faculty also run organizational gatekeeping activities according to an unconventional understanding of what

the qualities of an ideal graduate student are, and to that end, established a master's–Ph.D. bridge program to enhance Black, Latino/a, and Native American students' access and success. Third, program directors empowered staff to serve as institutional agents, and one of them has served as a cultural translator and agent of faculty learning to work with students across race. Finally, a core group of faculty, staff, and students have promoted the idea that they relate to one another as a family, and they demonstrate to one another (and to prospective students) that this metaphor is more than a cliché.

Connecting these themes is a collective, sustained effort by faculty, staff, and students to distinguish their program from a traditional physics department. This pattern is consistent with a core tenet of social boundary theory: that actors draw boundaries in relation to and often opposition to one another (Lamont & Molnár, 2002; Zerubavel, 1991).[9] The willingness of program stakeholders to rethink—and change—the normative boundaries associated with their subject matter, the qualities of ideal students, and their roles and relationships is perhaps the central, most fundamental explanation for their ability to sustain strong enrollment of women and students of color in the absence of affirmative action.

The work of cultural translation enacted by administrative staff may represent an additional boundary change mechanism not fully articulated in Tilly's (2004) framework. Recall that boundary change occurs through mechanisms that prompt or cause change (e.g., conversation, borrowing, encounter), as well as mechanisms that constitute the change itself (e.g., inscription–erasure, activation–deactivation, relocation). They modify: 1) relations on either side of a social boundary, 2) relations across the boundary, or 3) shared representations of the boundary itself (Tilly, 2004). Joe's role as cultural translator for Black students and mostly White faculty arose through multiple mechanisms. First, his routine *conversations* with faculty and students *activated* a racial boundary; that is, through these interactions, program members named race as a salient factor in situations where faculty had not recognized it as such. By surfacing cultural norms with which faculty were unfamiliar, Joe provided access to actionable information about Black students' educational experiences. This knowledge altered subsequent social interactions across the faculty–student boundary, partially *deactivating* the role of race in that boundary. Ironically, it was only by naming race as a boundary that can produce misunderstanding (even in trusting, supportive relationships), and then translating cultural norms, that Joe helped weaken racial difference as a barrier to student learning.

Cultural translation operated as a *relocation* mechanism, defined by Tilly as two or more constitutive mechanisms that connect to change the boundaries organizing action and interaction in a given setting (Tilly, 2004).

The *activation* and subsequent *deactivation* of race observed in translation depended upon *conversation,* which both reflected and cultivated trust between Joe and the students and between Joe and the faculty. The example of *relocation* in this diverse program evokes Carter's (2006) landmark study of diverse classrooms where "cultural straddlers" employ a variety of cultural practices and skills to "broker the boundaries among multiple cultural environments" (p. 324). Joe's ability to *deactivate* traditional boundaries by translating student cultural codes for faculty occurred through forms of *conversation* that may be unique to cultural straddlers. Further research is needed to explore cultural translation in educational settings and the ways cultural straddlers choose orientation boundaries within graduate programs.

IMPLICATIONS AND FUTURE RESEARCH

By highlighting specific access and inclusion efforts in a successful STEM graduate program and noting their relationship to boundary change processes, this paper adds to what we know about student access and success in graduate education. It contributes in particular to literature that emphasizes faculty and administrators' responsibility for creating learning environments in which underrepresented students have equitable opportunities and thrive (Bensimon & Dowd, 2012; Gasman et al., 2004; Golde & Dore, 2001; Lovitts & Nelson, 2000). We identified recruitment, selection, and retention efforts that parallel findings in Rogers and Molina's (2006) study of exemplary graduate psychology programs. Cultivating relationships with MSIs and reducing the significance of the GRE in the admissions process, for example, both facilitated unusually high enrollment of students of color. The supportive environment that AP faculty, staff, and administrators created is also consistent with research linking doctoral students' integration into supportive academic and social networks—both formal and informal—to their well-being, academic achievement, and professional outcomes (Espino, 2014; Hurtado et al., 2011; Lovitts & Nelson, 2000; Ong et al., 2011; Rogers & Molina, 2006). Finally, our data imply that faculty and staff proudly adopted a "join our family" philosophy akin to that which Lovitts and Nelson (2000) advised, as opposed to the more transactional "do your work and leave" (p. 46) approach so common in graduate education.

IMPLICATIONS FOR PRACTICE

Our analysis of one graduate program's construction of the intellectual paradigm, selection norms, professional roles, and climate suggests that other graduate programs would similarly benefit from making explicit and changing the symbolic boundaries in these domains. Graduate

programs might look closely at their curricula, recent dissertations, and faculty research to capture implicit messages about the type of knowledge that carries value in their program. Are professors more likely to be known for their contributions to theory or applied problems? In what ways do syllabi and/or course requirements expose students to ideas outside of one's own discipline?

With respect to selection norms, the Council of Graduate Schools recently released a major report outlining the importance of holistic review in graduate admissions, and some disciplinary organizations—including the American Physics Society—are actively working to encourage department-level admissions reforms as part of broader diversity efforts. Graduate programs and graduate schools should similarly examine the qualities of students who are admitted, who enroll, and who complete various graduate-level programs. Admitted students reveal faculty preferences, while those who enroll and complete reveal whom they have been more and less successful in attracting and serving. This type of analysis may be useful in determining how to balance investments in selection, recruitment, and student support.

Obtaining objective measures of how members conceptualize their roles and relate to one another may be more complicated. However, we found the focus group method (which gathers not only individual perspectives, but also the extent of consensus and disagreement) to be a powerful means of uncovering shared views about the unique roles and responsibilities that program staff played. Graduate programs working to improve the quality of relationships could similarly hold focus groups or informal meetings separately with faculty, students, and staff to learn whether there may be warrant for adjusting the expectations or authority that some hold. Relatedly, our experience comparing faculty, staff, and student perspectives implies that these roles may sometimes come with divergent perceptions of climate. Since climate is a multidimensional construct (e.g., Milem et al., 2005) with the quality of relationships making up only one dimension, faculty and students may not see eye to eye about what "climate" means, and this misunderstanding could produce misinformed efforts to redress climate-related problems. It is notable that although trusting relationships were a bedrock of the family-like community the core faculty, staff, and students tried to create, students (especially women and students of color) still sometimes relied upon staff to mediate difficult encounters with faculty.

However intuitive these areas of effort may seem, variation in disciplinary cultures will mean that different or additional areas of boundary work underlie successful equity efforts in monodisciplinary and non-STEM graduate programs. The specifics of successful efforts to address

intellectual paradigm, selection norms, professional roles, and climate may also be different in applied physics than they are in other fields, and different in other universities and institutional types than we found at the University of Michigan. Although generalizability from case studies is always limited, the four themes we identified as areas of boundary work offer promising angles for both future scholarship and organizational change in graduate education.

IMPLICATIONS FOR RESEARCH

What is most generalizable from our findings is the fundamental cultural change that comes about by manipulating symbolic and social boundaries. We hope this case study will stimulate education researchers to see and expose 1) the subtle boundaries that perpetuate inequities in other educational contexts, as well as 2) other boundary work efforts that reduce barriers to educational access and inclusion. All graduate programs and disciplines—and all educational institutions more broadly—have formal and informal boundaries that shape how educators evaluate and interact with students. To bring about more equitable outcomes, they must relocate those boundaries when they present disproportionately difficult barriers for historically underrepresented students. Although this is the first paper to examine boundaries in higher education, select scholars have examined boundaries in K–12 settings. For example, Carter (2006) challenged the "acting White" thesis by illustrating how low income Latino/a and Black students negotiated boundaries between peer and school contexts.

Questions for further research are also introduced by bringing a critical management perspective to the AP case. This angle might cast its founders' work as creating a new layer in the elaborate university bureaucracy rather than fundamentally changing the existing bureaucracy. AP strives to break down institutionalized barriers present in many fields, but it does so from a program that is small, relative to the physics department. Bensimon and Dowd (2012) argued that working for equity in STEM through small-scale programmatic efforts, such as programs like McNair and Meyerhoff, may be counterproductive in the long run by investing in a small group of students rather than trying to change the system that serves many students. Does having multiple entry points improve access? Or does it protect stratification by detracting attention from inequity in the organizational core? Questions like these merit empirical research as part of a long-term national agenda for equity in STEM and graduate education.

Any answer to the question of "What works?" will be context specific, in time and place. Research is therefore needed about whether the conditions we observed in AP were unique or also present in other STEM

graduate programs that have been successful graduating women and students of color. Do such programs' histories suggest varied paths to equitable outcomes? Or do their organizational trajectories bear significant similarities? How do equity efforts at the department level interact with institutional, disciplinary, and state policy contexts?

Founding the program may have been a boundary work project of "knock[ing] down the walls" that have historically excluded women, Black, Latino/a, and Native American students from physics at the most advanced levels. However, given the constraints present in even well-resourced institutions, the embeddedness of departmental equity efforts in other contexts, and the continual learning required of even well-intentioned leaders, applied physics' history demonstrates that that creating conditions to support access and inclusion is not a one-time event but an ongoing struggle.

NOTES

1. Although it is not the focus of this study, an adjacent mechanism for cultural change through graduate education is students' development of a critical consciousness about the academic environments in which they find themselves. As students reflect upon their experiences with disciplinary socialization, they may enter the professoriate with a commitment to resisting prevailing norms and values.

2. About labels: Due to our focus on graduate education, in which departments may administer multiple academic programs whose graduate students may or may not interact, we use the language of graduate programs rather than academic department but draw upon the available research about departmental cultures. We honor our research participants' complex identities, as well as the histories and struggles that produce the labels for those identities. For clarity and consistency, we use Black, Latino/a, Asian American, Pacific Islander, Native American and White for racial/ethnic identities, recognizing the distinctions between race and ethnicity and the heterogeneity within each of these categories.

3. Disclosure statement: No member of our research team had prior relationship with members of the applied physics program before this project. We learned about it through administrative data provided by the university in which the program stood out for its high rates of enrollment and degree attainment by people of color and women over the last five years.

4. Lamont did not deny the role of status struggle in the reproduction of inequalities (nor the roles of status struggle in habitus, social capital, and cultural capital). Rather, she added the drawing of symbolic boundaries as an additional mechanism. Other mechanisms may also be possible. One could relate these mechanisms by noting that organizations determine whom to exclude by drawing boundaries that separate those who do and do not have forms of social and cultural capital that the group has defined as valuable/desirable.

5. All participants have been given pseudonyms to protect anonymity, except the current and founding directors, and the university president at the time of the program establishment, who have given their consent to be named.

6. Three decades later, we can see that Roy's pragmatic approach of making the diversity conversation a matter of disciplinary perspective and race, rather than race alone, enabled him to launch a program that was progressive for its time. Recent education scholars have critiqued the practice of collapsing race with additional types of diversity, however, and others question the wisdom of using a discourse of diversity to justify equity-oriented efforts. This approach risks conflating the pursuit of difference with the pursuit of equity and can stymie subsequent efforts if diversity becomes mistaken for the goal rather than a strategy in service of equity (Ahmed, 2012; Bensimon, 2005; Chang, 2002). Pushing for diversity without being explicit about race can undermine racial equity by detracting attention from it (Shiao, 2004). While progressive for its time, Roy's strategy should not be read as a best practice across all contexts of time and place.

7. Program directors shared with us that one of the major drawbacks of a program structure was a lack of authority over faculty hiring. They recognized that this limited their ability to provide students with faculty mentors from similar racial and gender backgrounds.

8. On the political nature of defining what should be considered within the bounds of merit, Karabel (1984) wrote, "The very definition of 'cultivation' or, in the modern world of bureaucracies, 'merit' that predominates in a particular society expresses underlying power relations and tends, accordingly, to reflect the particular cultural ideals of those group that hold the power of cultural definition. By its very nature, the process of defining 'cultivation' and 'merit,' far from being neutral, is thus a profoundly political one" (p. 2).

9. Although our paper adopts a cultural sociological perspective, a closely related tenet from social psychology asserts that individuals define themselves (i.e., their identities) in relation to others. Cultural sociologists do note, however, that boundaries tend to be rooted in identities, and have amassed a rich body of scholarship that discusses the patterns of norms and behaviors associated with specific social identities.

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