

CLASSIFYING AND CRITIQUING EFFORTS TO ADDRESS INEQUITIES IN PHYSICS

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ACKNOWLEDGEMENT

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MARKERS OF DIFFERENCE

- Sociocultural markers – the ways that cultures are defined in a region – “language” is an example
- Sociopolitical markers – are often themes in the media and society that influence power and politics - within the US “race” is an example (Allen & Bagozzi, 2001)
- Sociohistorical markers – relate to privilege and position within a society and can be based on past or present laws and societal views – “gender” is an example within the US
- This does not include difference related to preparation; though, sometimes there is overlap
- Difference between focus on K-12 education vs undergraduate ed. vs graduate ed.

COMMON MARKERS OF DIFFERENCE IN PHYSICS EDUCATION RESEARCH (PER)

- “NSF INCLUDES is especially interested in broadening participation for those groups historically underrepresented in STEM fields such as African Americans, Hispanics, Native Alaskans, Native Americans, Native Hawaiians, Pacific Islanders, persons with disabilities, women and girls, and persons from economically disadvantaged backgrounds” (NSF, 2020)

WHY STUDY MARKERS OF DIFFERENCE IN PER

- Addressing Workforce needs (NSF, 2020)
- Population Diversity and Representation
 - Identify[ing] approaches to make science and engineering education broad and inclusive (NRC, 2012)
- Social Justice (Atwater, 1999; Atwater, Butler, Freeman, & Parsons, 2013; Ladson Billings, 2007)

CHARACTERIZING DIVERSITY EFFORTS

- “the better we understand how identities and power work from one context to another, the less likely our movements for change are to fracture” (Crenshaw, 2015)

Naming and acknowledging

Affirming Diversity

Removing Barriers

NAMING AND ACKNOWLEDGING DIVERSITY

Scholarly Publications

- 2018 and 2019 Physics Education Research Conference Proceedings (PERC) – 15.6% of papers
- Focused Collections
 - Gender in physics in *Physical Review – Physics Education Research* (2016)
 - Race and Physics Teaching in *The Physics Teacher* (2018)
 - Sex, Gender, and Physics in *The Physics Teacher* (2020)
 - Resource Letter: Gender and Physics in *American Journal of Physics* (Blue, Traxler, & Cochran, 2020)

NAMING AND ACKNOWLEDGING: SPECIAL REPORTS

- Statistical Reports

American Institute of Physics (AIP)' Statistical Research Center

- Task Force Reports

- American Physical Society's Report (APS) on Climate for LGBT Physicists (2016)

- AIP's Report on African American's bachelor degree attainment (Team Up)

- APS and the American Association of Physics Teachers Membership Climate Reports

- The APS Gazette

NAMING AND ACKNOWLEDGING DIVERSITY

Non peer-reviewed articles, blogposts, and social media engagement

- “The self-construction of Black women physicists” (Prescod-Weinstein, 2017)
- “Reclaiming my state of mind: Why I’m leaving my PhD program (Rodriguez, 2019)
- “When you love physics, but physics doesn’t love you” (Perry, 2019)

NAMING AND ACKNOWLEDGING: BENEFITS

- Starts the conversation on the experiences of people marked by difference
- Helps to focus on actionable steps
- Brings awareness to who longs for diversity in physics and what markers of diversity they long for

NAMING AND ACKNOWLEDGING: REVEALS WHAT'S MISSING

- There are no statistical reports on LGBTQ physicists
- There are major gaps in the literature on the experiences of physicists from lower socioeconomic backgrounds
- Research on disability and physics was absent for some time, but is recently beginning to increase
- Failure to acknowledge intragroup differences
 - Panethnic categorization (eg. Asian, Hispanic)
 - Underrepresented Minorities

NAMING AND ACKNOWLEDGING: REVEALS WHAT'S MISSING

- PER subjects, as a whole, are better prepared mathematically and are from a narrow and unrepresentative subset of our intended target physics student populations.(Kanim & Cid, 2020)
 - Oversamples white and wealthy students
 - Very little research on high school students
 - Very little research on students at community colleges (two-year colleges)

AFFIRMING DIVERSITY

- The terminology used in research
- Becoming familiar with and following the guidelines created by people from marginalized and minoritized populations
 - LGBT+ inclusivity in physics and astronomy: A best practices guide
 - Emerging Reflections from the People of Color at PERC Discussion Space
 - People of Color in Academia

AFFIRMING DIVERSITY

- Supporting organizations focused on Affinity Groups within Physics
 - NSBP, NSHP, SACNAS, AISES
- Professional Society – Committees, Task Forces, and Resources
- Collective Statements and Actions
 - #Strike4BlackLives, #ShutDownStem, #ShutDownAcademia
 - Nearly 2500 physicists signed a response to the Justices of the Supreme Court of the United States

REMOVING BARRIERS

- The Graduate Record Exam (GRE) is a barrier to graduate admissions in physics

THE GRE'S EFFECTIVENESS

- Petersen, S. L., et al (2018). Multi-institutional study of GRE scores as predictors of STEM PhD degree completion: GRE gets a low mark. *PLoS one*, 13(10), e0206570.
 - GRE Verbal (GRE V) and GRE Quantitative (GRE Q) scores were similar for women who completed STEM PhD degrees and those who left
 - GRE scores were significantly higher for men who left than counterparts who completed STEM PhD degrees
 - GRE scores also failed to predict time to degree or to identify students who would leave during the first year of their programs.
- Miller, et al (2019). Typical physics Ph. D. admissions criteria limit access to underrepresented groups but fail to predict doctoral completion. *Science Advances*, 5(1), eaat7550.
 - Physics GRE and Verbal GRE have no association with PhD completion
 - Quantitative GRE only has an association with PhD completion if US students are looked at as a group and all students regardless of citizenship; not so if men and women were looked at independently

REMOVING BARRIERS

- The Graduate Record Exam (GRE) is a barrier to graduate admissions in physics
 - Cochran, Hodapp & Brown, 2017
 - Miller & Stassun, 2014
 - Posselt, Hernandez, Cochran, & Miller, 2020
 - Miller, Zwickl, Posselt, Silvestrini, & Hodapp, 2019
- Many physics departments in the US use the GRE in making admissions decisions
 - Scherr, Plisch, Gray, & Potvin, 2017
 - Potvin, Chari, Hodapp

STUDY I

- Julie Posselt, Theresa Hernandez, Geraldine Cochran, and Casey Miller
- Posselt, J., Hernandez, T., Cochran, G.L., & Miller, C. (2019). [Metrics first, diversity later? Making the short list and getting admitted to physics PhD programs](#), *Journal of Women and Minorities in Science and Engineering*, 25(4), 283-306.
- Attiyeh & Attiyeh (1997)
 - Three predictors of admissions to graduate programs
 - GRE Scores
 - High college. Grades
 - Attending selective colleges
 - Predictors privileged applicants from groups overrepresented in graduate education
 - White applicants
 - Male applicants
 - Wealthy applicants

GRE CUT-OFF SCORES

- Miller & Stassun (2014)
 - Typical cut-off scores
 - Exclude 75% of Mexican American applicants
 - Exclude 50% of White applicants
 - Exclude 25% of Asian Americans applicants
 - Almost all African American applicants
 - Posselt (2016)
 - Shortlists created by filtering applicant pools based on
 - GRE scores
 - Grades, which was contextualized by undergraduate college reputation
 - Applicants who made the short list were subjected to more holistic review (broad range of candidate qualities, personal attributes, and non-cognitive variables)
- “First you have to be above a bar , then ask the diversity question.”

RESEARCH DESIGN

- Objectives
 1. Is metrics first, diversity later verified by quantitative evidence?
 2. Does reliance on GRE scores undermine the opportunities for women, Black, and Latinx applicants
- Data Analysis
 - Admissions data from 6 large, selective physics programs
 - Used various academic and demographic characteristics as predictors for two outcomes (dependent variables)
 - Being short listed
 - Being admitted
- Independent variables
 - Demographics – nationality, gender, race/ethnicity
 - Undergraduate GPA
 - GRE test scores (verbal, quantitative, and writing) and Physics GRE

LIMITATIONS

- Findings can only be generalized to the sample programs, which were not randomly selected
- Programs included are part of a network aimed at broadening participation in graduate physics education
- Programs are prone to decision-making biases of large, successful organizations

FINDINGS

- Women applicants have both greater odds of being placed on the shortlist and greater odds of being admitted if they are on the shortlist in all models.
 - The same is not true for Black/African American and Latinx applicants.
- When controlling for GPA, and GRE general scores, the subject test is a significant predictor for Latinx but not Black/African American applicants' placement on the shortlist.
- When controlling for Physics GRE and undergraduate GPA and General GRE scores, Black/African American applicants already on the shortlist, had greater odds of being admitted.

IMPLICATIONS FOR RESEARCH

- We need data gathering efforts across institutions, in order to create larger sub-samples of students from underrepresented groups.
- Given the large fraction of international students in physics, it would also be valuable to analyze whether programs that receive large numbers of applications from international students put greater weight on the VGRE and WGRE scores, perhaps informally using these measures as proxies for English ability.
- More research, on the role that socioeconomic status plays in students' opportunities within the field of physics.
- Future research should consider study designs that allow for inclusion of Native Americans, Southeast Asian, gender non-conforming, LGBTQ, and other rarely studied populations in STEM

IMPLICATIONS FOR PRACTICE

- Rigid reliance on the GRE (i.e., especially when faculty are constructing the shortlist) may be preventing underrepresented groups from advancing in the admissions process.
- Implementing formal systems of holistic review offers one possibility for a more thoughtful and complete, but still systematic, approach to admissions decision-making.
- Faculty must become comfortable discussing race in general – especially in relation to graduate admissions.
- With very few Black/African American, Latinx, and Indigenous students being admitted to PhD physics programs, creating inclusive environments where they can thrive is essential.

RECENT RESEARCH ON GRADUATE EDUCATION IN PHYSICS

- Potvin, G., Chari, D., & Hodapp, T. (2017). Investigating approaches to diversity in a national survey of physics doctoral degree programs: The graduate admissions landscape. *Physical Review Physics Education Research*, 13(2), 020142.
 - National survey of grad directors of physics PhD programs
 - Findings in this study indicated that many institutions rely on a narrow band of admissions criteria and don't consider race/ethnicity or gender in their admissions decisions.

RECENT RESEARCH ON GRADUATE EDUCATION IN PHYSICS

- Scherr, R. E., Plisch, M., Gray, K. E., Potvin, G., & Hodapp, T. (2017). Fixed and growth mindsets in physics graduate admissions. *Physical Review Physics Education Research*, 13(2), 020133.
 - Qualitative study investigating the characteristics of applicants committees sought to admit into their program
 - Results indicated that physics graduate admissions committee members exhibit a fixed mindset even when striving to prioritize diversity in admissions

PRE-ADMISSIONS – THE CULTURE OF POWER IN PHYSICS

- “Culture of Power (Delpit, 1988)”
 - Barton and Yang define the culture of power as a "set of values, beliefs, ways of acting and being that for sociopolitical reasons, unfairly and unevenly elevate groups of people mostly white, upper and middle class, male and heterosexual (Barton & Yang, 2000).”
 - Barton asserts that barriers are a product of human invention that have been legitimized and have often been accepted as normal.

5 ASPECTS OF THE CULTURE OF POWER

- “Culture of Power (Delpit, 1988)”
 1. Issues of power are enacted in classrooms.
 2. There are codes or rules for participating in power, that is, there is a culture of power
 3. The rules of the culture of power are a reflection of the rules of those who have power
 4. For those who are not already a participate in the culture of power, being told explicitly the rules of that culture make acquiring power easier
 5. Those with power are frequently least aware of-or at least willing to acknowledge-its existence. Those with less power are often most aware of its existence.

IS THERE A CULTURE IN PHYSICS”

- Ethnography has been used to study the culture within the high energy physics community (Traweek, 1988).
- Gonsalves (2012) studied how women graduate students became a part of the graduate physics community and found a gendered experience.
- “The culture of physics, including physics departments and physics courses, has been designed by and for men” (Traxler, Cid, Blue, & Barthelemy, 2016)
- The culture of physics is not only masculine, but sexist (Barthelemy, McCormick, & Henderson, 2016).
- “There are common racialized experiences that Black physicists encounter” (Hyater-Adams, Fracchiolla, Finkelstein, & Hinko, 2017).
- There are common experiences that Women of Color face in physics that make them feel isolated within the physics community (Johnson et al., 2017)

ISSUES OF POWER ARE ENACTED IN THE GRADUATE ADMISSIONS PROCESS.

- Those with power over prospective graduate students
 - faculty on the graduate admissions committee
 - research advisors for undergraduate research experiences
 - departmental/undergraduate program advisors
 - physics instructors.
- Earning a PhD in physics prepares students for a variety of career prospects often resulting in
 - a great deal of respect
 - often unquestioned mark of intelligence
 - financial gain

THE RULES REFLECT THOSE IN POWER

- “The rules of the culture of power are a reflection of the rules of the culture of those who have power (Delpit, 1988)”
 - Physics faculty – 79.2% White, 14.3% Asian, 3.2% Hispanic, and 2.1% African American, and 1.2% Other (AIP SRC, 2014)
 - Physics faculty – 22% Women at Assistant Professor level and 8% at Full Professor level (AIP SRC, 2013)
 - Physics faculty – 16 Black Women, 11 Hispanic Women/Latinas (AIP SRC)

TWO MORE ASPECTS OF THE CULTURE OF POWER

- “For those who are not already a participant in the culture of power, being told explicitly the rules of that culture make acquiring power easier (Delpit, 1988)”
- “Those with power are frequently least aware of—or at least willing to acknowledge—its existence. Those with less power are often most aware of its existence (Delpit, 1988)”

WHAT ARE THE BARRIERS TO PARTICIPATING IN GRADUATE PHYSICS?

- The APS Bridge Program
 - **Aims** to increase the number of African American, Hispanic American, and Native American students obtaining PhDs in physics
 - **Offers** a free common application that is shared with numerous physics graduate programs
 - **Offers** professional development for students
 - **Offers** connections to faculty mentors and other students placed in bridge programs nationwide
- Eligible students
 - Must have completed a BS in physics or a closely related field
 - Have either not applied to a graduate physics program OR have applied, but were not accepted
- The National Advisory Board notes that many students who apply to the APS Bridge Program are immediately accepted into PhD programs.

RESEARCH DESIGN

- Content Analysis
 - Applicant responses to 2 questions
 - 1 open-ended
 - 1 multiple-choice
- 9 Semi-structured interviews
 - Interview protocol
 - Based on codes from the content analysis
 - Participants in the 2016 cohort of the APS Bridge Program
 - Demographics varied amongst participants, but are not shared to maintain confidentiality and in some cases anonymity

DATA COLLECTION

- Question 1: Have you applied to any graduate programs?
Students who answered Question 1 with no: All Cohorts

Cohort	# who answer No	Percentage of applicants
2013	14	45%
2014	12	29%
2015	25	43%
2016	44	46%
All Cohorts	95	42%

DATA COLLECTION

- Of the 95 applicants that responded "No" to applying to graduate school:
 - All 14 applicants from 2013 did not include a response.
 - All 81 applicants 2014 – 2016 responded.
 - Average Word Count is 15 words.
 - Highest Word Count is 545.
 - Lowest Word Count is 6.

CODING APPLICANT RESPONSES – CONTENT ANALYSIS

Code	Words included	Number of Responses Coded	Percentage of Responses coded
GRE	GRE	27	33
research	research	19	23
grade	grade(s), GPA	12	15
time	deadlines, time	11	14
finances	financial, money, economical	8	10

INTERVIEW PROTOCOL

- When did you first start thinking about graduate education/graduate school in physics? Tell me about that.
- Did you discuss the possibility of pursuing graduate education in physics with anyone?
- What would you say are the biggest challenges to someone deciding to pursue graduate education after finishing a bachelor's degree?
- What would you say are the biggest obstacles to students getting accepted into graduate physics programs?
- Did you seek out any help on how to prepare an application to graduate school? If so, tell me about what resources you used.
- If not mentioned, I asked about the codes used in Phase I of the study.

THE GRE IN THE CONTENT ANALYSIS

- Most frequently used word (33% of responses)
- General GRE, Subject GRE, and unspecified
 - “There is needed improvement in my Physics GRE and General GRE”
 - “I did not take the general GRE”
- Combined with other codes
 - “Was not able to take the GREs in time for the PhD programs”
 - “I haven’t taken the GRE for economical problems.”
 - “It was a money issue. I did not have to the money to apply or even take the GRE”

THE GRE IN THE INTERVIEWS

- “Yes, definitely and I ... for some reason totally forgot about that - how huge that is when you’re applying.”
- *I feel like the hardest thing is the [general] GRE. I hate the thought of standardized [tests] telling me if I’m competent enough to get into a program.*
- *I took it [the Physics GRE] ...three times...and ...[I wasn’t]...happy with those scores...I prepared so much and I was ready and I didn’t do well...and the General GRE...I knew there were programs that could help but they were expensive...I’m already investing [money to take the test].*
- Previous research has focused on the impact of graduate admissions in physics, due to the results/scores on the exam. This group of students, though, never even make it to that pool of applicants.

THE GRE'S EFFECTIVENESS

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RESEARCH EXPERIENCE

- Research experience –second most frequently occurring word (23 percent of responses)
 - “Based off of my grades and no research experience I didn’t think I would be accepted.”
 - *Some friends... felt scared to apply to a program and not be accepted because their research experience was not enough, and in a sense it’s kind of true because in grad school you do mostly research, but I mean, I guess not everyone has the same opportunity. I feel like I was lucky... a lot of the students that don’t have the good grades... don’t get to do REUs which in turn, don’t get the research experience.*

RESEARCH EXPERIENCE

- Irving, P.W., & Sayre, E. C. (2015). Becoming a physicist: The roles of research, mindsets, and milestones in upper-division student perceptions. *Physical Review Special Topics-Physics Education Research*, 11(2), 020120.
- Physicists are researchers
 - *“Undergraduate research experience can be a pivotal experience in a student’s trajectory to becoming a member of the community of practicing physicists”*
 - *“When students engage in under graduate research, they are being guided by more central members of the community of practicing physicists through engagement in the authentic practices of that community. Conducting research also effect students’ perceptions of what authentic practice looks like for a physicist.”*
 - *“Are we forcing out potential physicists because, as an undergraduate, they do not conform to the expectations of the central members of the community of practicing physicists?”*

GPA OR GRADE(S) IN CONTENT ANALYSIS

- GPA – (15% of applicant responses)
- “I do not meet the GPA requirement for any graduate programs I have encountered.
- “my GPA is poor and I do not think I have the chance to get into a good program.”
- “I need to get my grades up to a level that would help me be competitive applying to graduate school.”
- “Based off my grades and no research experience, I don’t think I would be accepted.

GPA OR GRADE(S) IN INTERVIEWS

- *I think...because of my grades...having an F in my transcript...and maybe even GRE scores...you kind of tell yourself that you're not smart enough to get into that program because your grades reflect how smart you are. I mean that's definitely not true but that's basically what...I think admissions think [sic] about me.*
- *This is a barrier!*

DEADLINES/TIME

- Deadlines/time (14%)
- "I didn't begin to consider graduate school until two months ago. By that time, a lot of deadlines had come to pass."
- "As a result, I missed many application deadlines."
- Not coded under this category:
 - "I am unclear about where I should go and what types of research I should look to do."
- *From interview*
 - *Even though my professors had talked to me about graduate school...I didn't realize that the deadlines were in the first semester of my senior year...but that was my fault for not taking more heed..."*

FINANCIAL

- Financial (10%)
 - *“I think that the first challenge that comes across my mind is just financial. Sometimes you want to keep going on what...you really want to do, but you have your family that need so much support.”*
 - *“A lot of time family is always discouraging you from pursuing higher education ... You need to make some money, so after you graduate...with your bachelor’s degree you should start working and make money and later on you go to get your higher education.”*
 - *“in the beginning, I didn’t know that I was going to be paid to go to grad school and so after I learned that was less of a worry...a lot of people worry about...taking loans and ... when [they] will...pay them back.”*

TIFFANY

- Encouragement – “Ms. [Tiffany] you need to go get the PhD. It’s a waste of time and money to get a masters. Get the PhD.
- “I have conference presentations. I have research under my belt more than two year’s worth. I have two components and I have GPA as well. So, my GRE scores were, I guess you can say 8 or 9 points away from an average score. ...I had very sufficient research experience. I was able to publish four times, you know as an undergrad. So, I knew that –even though I know other students have that, you know, advantage as well at their own institutions...I thought that would help me stand out more the fact that I was published and then I won [at an] actual national conference. I actually won in my category.

TIFFANY

- Discouragement – “where I would be able to get accepted if I were to pursue a PhD because it’s very competitive and that’s what ultimately discouraged me to even attempt to apply.”
- “I am African American and being an African American as a woman going to a PhD program, I mean the scout plus the students they’re all majority you know Caucasian or Asian... It kind of discouraged me. I don’t blame the race thing for me not getting into school. I don’t say that at all. It kind of discouraged me. Just me thinking well maybe I’m just not good enough to be in a PhD program. Maybe I’m not good enough. There was a lot of thought that went into that and a lot of heart-breaking tears.

CONCLUSIONS FROM STUDY I

- There is a culture of power in physics that has an impact on who can and cannot become a PhD physicist
- This culture of power results in human-made barriers to some people accessing power through admissions to graduate programs
 - Many of these barriers are not related to success in PhD programs
 - Many of these barriers disproportionately impact individuals from minoritized ethnic/racial groups and individuals who are socio-economically disadvantaged

IMPLICATIONS FROM STUDY I

- Change the rules!!!
- Until the rules change, and those in power become more diverse, if we are to broaden participation in physics, we must make those with less power aware of the rules.
 - Demystifying the graduate school application process
 - Explaining how graduate school might be funded
 - Helping students with financial disadvantages determine schools to which they should apply
- Until the rules change, we must support those who are navigating the system and trying to overcome barriers,
 - bridge programs
 - offering research experiences to non-traditional students

HOW WE CHANGE THE RULES

- We must simultaneously work to change the rules.
 - One way in which to do this is to rethink the graduate admissions process and revise as needed.
 - Another way is to rethink what it means to be a physicist and what constitutes doing physics.
 - Engage in equity-oriented research and equity-oriented decision making.

THANK YOU!