



Interacting with Ruling Relations: Engineering Graduate Student Experiences of Discrimination

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ABSTRACT

Background: The retention of traditionally underserved students remains a problem across graduate engineering programs. Women and men of color and white women leave graduate programs without their intended degree at higher rates than their white male peers. Experiences of discrimination may hinder degree progress for students with marginalized identities.

Purpose/Hypothesis: This study investigated women and men of color and white women's experiences of discrimination in graduate engineering programs through the lens of ruling relations.

Design/Methods: Semi-structured qualitative individual interviews explored the experiences of doctoral engineering students. Comparative analysis methods uncovered themes derived from participants' experiences of discrimination in engineering graduate education.

Results: Women and men of color and white women experienced discrimination from peers, faculty, and advisors in settings such as classrooms, offices, and labs. Based on the themes and ruling relations identified, three significant findings can be distilled: (1) marginalized students recognize some of the norms and systems that marginalize them; (2) interactions that marginalize students are set into the social fabric of engineering and include excluding some students while including others; and (3) everyday interactions sustain and reproduce the oppressive norms.

Conclusions: This study offers perspectives that can help graduate program directors and graduate advisors and faculty cultivate equitable environments and assist peer graduate students in understanding their marginalized peers. The implications of this work point to steps necessary to improve the graduate engineering environment for marginalized students.

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INTRODUCTION

Engineering continues to see significant disparities in race/ethnicity and gender representation at the doctoral level due to marginalization, oppression, and exclusion (Bancroft, 2018; NSF & National Center for Science & Engineering Statistics, 2019). Engineering doctoral students' experiences of discrimination, sexism, racism, and microaggressions target students based on personal or social characteristics further perpetuating these disparities. These experiences of racism and sexism help explain differences in rates of participation, attrition, and degree completion for traditionally underserved students (TUSs) in engineering (e.g., Bancroft, 2018; Burt et al., 2019; Dutta, 2015; Hall, Schmader & Croft, 2015; McGee, 2016; Miles, Brockman, Naphan-Kingery, 2020; NSB, 2018; O'Meara et al., 2018; Ong et al., 2011; Sowell, Allum & Okahana, 2015). This work adds to this growing body of literature on the TUSs' experiences in engineering doctoral education by exploring the racism and sexism that emerges in interpersonal interactions as an indicator of ruling relations.

GROUNDING TERMINOLOGY

Throughout this work, the term TUS is used to emphasize doctoral education's role in propagating and maintaining inequitable systems that marginalize, oppress, and exclude women, marginalized racial and ethnic groups (African American or Black, Hispanic or Latinx, Pacific Islander, Native American or First Nations, Alaskan Native), first-generation, sexual and gender minorities, and individuals who reside at the intersection of multiple marginalized identities (Bancroft, 2018; Banda, 2012; London, Rosenthal, Levy & Lobel, 2011; Sue et al., 2007). We prefer the term *marginalized identities* over *minoritized identities* to emphasize the treatment of students based on their identities rather than their numerical representation. At the same time, we emphasize that marginalized identities often receive inadequate educational resources by using the term underserved groups. Simultaneously, we are unable to include all underserved groups of interest. Particularly, non-binary and gender non-conforming people are not represented in this work due to the unique oppression of these gender identities that often are distinct from oppression of women. Similarly, we prefer *women and men of color* over *people of color* to highlight the differences associated with the intersection of race and gender in discrimination experiences between women and men of color.

In this work, the term *discrimination* highlights active sexism and racism enabled by ruling relations. Discrimination refers to the rights, privileges, expectations, courtesies, and access assumed by and granted to white men and denied, withheld, or limited for women and men of color, and white women. While similar, bias represents the distinct concept of preference or favoring, either conscious (explicit) or unconscious (implicit), of one group over another (Daumeyer et al., 2019). The distinction is necessary to see that discrimination and bias may or may not be tied together in a cause-and-effect relationship; instead, both exist in society in ways that perpetually influence our actions, stereotypes, and interactions. This research does not require categorization of a specific experience as an experience of discrimination or an experience of bias; rather, the experience provides meaning for the students' experiences, as such we use discrimination throughout the manuscript.

RULING RELATIONS

Our exploration of discrimination and subsequent marginalization in engineering is framed by the concept of ruling relations. Student experiences help identify and articulate ruling relations within the educational system. Educational systems as designed, including engineering doctoral education, do not serve students equally, resulting in additional hurdles for and the suppression of those that are not white male students (Hanson, 1996; Pawley, 2017). These educational systems enact *ruling relations* that are baked into institutional practices so securely that programs targeted at reducing racism and sexism do little to disrupt or remedy inequitable educational and employment outcomes for minoritized groups (Pawley, 2019).

O'Meara (2018) describes ruling relations as the "everyday norms, assumptions, logics, and social interactions that structure people's lives" (p. 205). Borrowing this conceptualization

helps us describe the unwritten rules and norms that govern interpersonal relationships in engineering doctoral education. Further, ruling relations provides a lens to examine the norms and assumptions that define, restrict, support, and replicate engineering doctoral student experiences and interpersonal relationships. Within engineering education, Pawley's (2019) work identifies ruling relations within undergraduate education. The most pertinent example to this work is her identification of engineering assumptions that define 'the ideal student' as a "young, single, white male" (Pawley, 2019, p. 13). The assumption that engineering students fit this "ideal" marginalizes all students with lived experiences or identities that do not conform.

We find two ideas useful in framing how TUSs' experiences demonstrate ruling relations in engineering: (1) ruling relations create and support day-to-day interactions based upon hierarchically structured doctoral education programs and relationships between students and faculty, and (2) ruling relations support the subtle and explicit forms of discouragement that obstruct TUSs. These challenges are not unique to engineering disciplines, but they may undermine the engineering community's best efforts to be inclusive and effective in building a diverse and globally competitive profession. Our study accepts the premise that engineering doctoral education contains ruling relations that embody norms of behavior and interaction while asking the following question:

How do traditionally underserved and marginalized engineering doctoral students' experiences of discrimination in their interpersonal interactions identify and illuminate discriminatory ruling relations within engineering doctoral education?

In theoretical terms, we accept the insight that ruling relations embedded in the macro-level socio-structural hierarchies reflect racist and sexist social norms and occur within interpersonal interactions. However, engineering's ruling relations do not immediately reveal how individuals experience those interpersonal hierarchies. Investigating students' lived experiences assists in identifying the ways interpersonal interactions manifest and reveal ruling relations.

LITERATURE REVIEW

Engineering doctoral students' lived experiences provide an opportunity to further uncover and identify ruling relations within interpersonal relationships that shape experiences with discrimination and bias in engineering doctoral education. Past engineering doctoral education research provides rich examples of engineering students' lived experiences of discrimination within interpersonal relationships (e.g., Bancroft, 2018; Burt, Williams & Palmer, 2019; Miles, Brockman, Naphan-Kingery, 2020; O'Meara et al., 2018; Wang & Degol, 2017). Along with conversations centered on race and ethnicity, research also highlights how commonly accepted ruling relations in interpersonal relationships guide and support negative assumptions about women's place in graduate STEM education (Wang & Degol, 2017) and undermine factors that predict retention (Dutta, 2015; Robnett, 2016). While these scholars did not use ruling relations conceptually, their work offers guidance on what ruling relations may exist in engineering doctoral education.

Research investigating ruling relations in STEM (science, technology, engineering, and mathematics) departments has shown, "Students experienced isolation and a lack of community, an environment that stressed *individualism and competition, and hierarchical structures* [emphasis added] in their STEM departments that made them question whether they belonged and could succeed" (O'Meara et al., 2018, p. 205). The same ruling relations may personalize discrimination by informing interpersonal interactions and relationships. Discrimination experiences and their effects have been documented throughout research on engineering doctoral education. However, this body of work has not articulated the systems of ruling relations that support and allow discrimination experiences to continue. The rest of the theory section highlights the ruling relations that were hypothesized based on available literature and were examined in our qualitative study.

The ruling relations of isolation and a lack of community define engineering doctoral education through requirements of total devotion to tasks while devaluing family and communities that support TUSs' interest and pursuit of advanced degrees. Burt and colleagues' (2018, 2019a, 2019b)

work with Black men in graduate engineering programs found that Black men faced racialized and gendered interactions from peers and faculty, reflecting discrimination and bias, often resulting in social isolation. Black men's experiences illustrated ruling relations that allowed disrespectful communication and tolerated discrimination and microaggressions (Burt, Williams & Smith, 2018). While creating unsupportive environments, ruling relations foster systems that devalue Black men's assets that foster persistence in graduate education, including family, spiritual/faith community, and undergraduate mentors (Burt, 2019b). Further, these unsupportive environments restrict access to interpersonal social networks and other forms of capital that foster identity development and a sense of belonging, two factors that drive persistence (Bancroft, 2018; Martin, Miller & Simmons, 2013; Martin, Simmons & Yu, 2013; Yosso, 2005).

Individualism, competition, and hierarchical structures often emerge as characteristics of educational defaults in engineering doctoral education in ways that hint at but do not illuminate ruling relationships. The apprenticeship model of doctoral education, advisor relationships, and professionalization exemplify structural defaults to ensure development as an advanced engineer. However, the defaults and expectations that underlie these models perpetuate unfair treatment, discrimination, and systematic othering of traditionally underserved students. Existing interpersonal advisor relationships allow disrespectful and microaggressive communication styles between advisors and Black men advisees (Burt et al., 2019b). These defaults inform the professional ideals that socialize students into norms and expectations for their professional engineering roles and relationships (Pawley, 2019; Dryburgh, 1999; Frehill, 2004). However, the professionalization process includes ubiquitous biases in evaluations of excellence and professional behavior that mask the less obvious expression and interpretation of white male interpersonal relationship norms embedded in and enabled by ruling relations (Pawley, 2019; Dryburgh, 1999; Frehill, 2004).

RESEARCH QUESTIONS

Existing literature identifies discrimination as a problem in engineering doctoral education. Rather than repeating previous research to categorize and articulate these experiences, we build off of these foundations to understand the unique systems and functions in engineering that perpetuate and allow for discrimination experiences to continue. While Burt et al. have explored these issues specifically for Black male engineering graduate students, the ways ruling relations are revealed by discrimination experiences of white women, women of color, and men of color from other backgrounds remains unclear. We seek to address this gap in the literature guided by our broad question, "How do traditionally underserved engineering doctoral students experience discrimination and social biases in their interpersonal interactions within the context of engineering doctoral education?" With this question in mind, we asked three specific research questions: 1) How do doctoral TUS experience discrimination? 2) How do student experiences highlight the way ruling relations emerge in interpersonal relationships? and 3) How do the discrimination experiences described emerge from the ruling relations that empower educational hierarchies and power differentials within academic culture? In answering these questions, our purpose focuses on identifying the systematic and widespread roots in engineering doctoral education that require change and restructuring to encourage and engage students who have historically faced discrimination in engineering higher education.

METHODS

As part of a larger research project to develop a scale of experiences of gender and race/ethnicity discrimination, we conducted semi-structured qualitative interviews with doctoral engineering students. We used comparative analysis to highlight, situate, and specify the ruling relations that inform students' experiences within engineering doctoral education. Specifically, Engineering doctoral students participated in 60-minute qualitative semi-structured interviews about their experiences and relationships in graduate school. A social constructivist approach guided the development of the interview protocol and analysis of interviews (Hesse-Biber, 2017).

The social constructivist paradigm informed the data-making process as it allows for recognition of the construction of participant narratives in interaction with the interviewer and comparison and interpretation of narratives by the research team to identify ruling relations embedded in sexist and racist power distortions within engineering. Students' perceptions of their experiences shape their interpretations of behavior and responses to others. Here, the importance is in the students' memory and interpretation of their experiences rather than measuring or defining an objective reality. The social constructivist paradigm focuses on the ways participants' experiences and perceptions create their reality (Hesse-Biber, 2017). This paradigm is instrumental in identifying the ways TUSs are required to construct space for themselves to generate meaning from experiences and relationships in a field dominated by white and Asian men.

DATA QUALITY AND TRUSTWORTHINESS

Making qualitative data requires consistent processes to ensure consistent gathering and recording of data (Walther, Sochacka & Kellam, 2013). Pilot testing of our interview procedure and protocol assisted in ensuring our research processes were consistent. Based on the first two pilot interviews, the interviewer's (the first author) positionality needed elaboration in the introduction of the interview (Bahnon, Cass & Wyer, 2019). Qualitative research benefits from the examination of interviewers' positions in relation to not only the research and analysis, but also in relation to the interview participants (Green, Creswell, Shope & Clark, 2007; Merriam & Tisdell, 2015; Hesse-Biber, 2017). Additional detail in the interviewer's introduction explained the interviewer's interest in engineering doctoral student experiences due to his husband's experiences in another STEM field in subsequent pilot interviews (Appendix 1; Bahnon, Cass & Wyer, 2019). Pilot testing indicated the revised introduction provided the necessary context for participants and increased the rapport and trust between the interviewer and participants (Bahnon, Cass & Wyer, 2019). The revised introduction was used for all interviews after the third pilot interview.

Further, handling the data required attention to process, record keeping, and concept tracking to ensure process reliability (Walther, Sochacka & Kellam, 2013). Drawing on extensive interview experience, the interviewer recorded extensive field notes and memos to highlight salient narratives and assist in appropriate probing follow-up questions during and immediately following each interview. In addition, the interviewer used field notes and memos to bracket assumptions and personal responses to participants' narratives (Gearing, 2004). Field notes and memos were used to explore the context in interviews but were supplemental to the data analysis. Debriefing with the research team assisted in maintaining perspective and a focus on participants' experiences. Additional detail about making and handling the qualitative data are described in the following sections.

PROCEDURE

Participants in the Grads Project (NSF-DUE #1535453, #1535254), a national survey about engineering identity, motivation, and graduate school experiences, volunteered to be contacted for additional research (Cass et al., 2018; Perkins et al., 2018a). Eligibility requirements for participation in our interviews included: 1) at least 18 years old; 2) a woman or man of color or a white woman; 3) currently or recently (less than one year ago) enrolled in a doctoral engineering program. Selection variables for participants were based on self-identified demographics in the Grads Project dataset. Participants who self-identified as non-binary or transgender were not included in our sample for this project. The discrimination experiences of transgender, non-binary, and other gender identities represent distinct gender discrimination and transphobic characteristics that require a separate study and specific attention to lived experiences that were beyond the scope of this project (e.g., Siegel, 2019). Women and men of color and white women were sought as participants since they were more likely to have experienced discrimination in their doctoral programs than their white male peers. We included Asian men in the sample to include their experiences as a group marginalized in society. Their experiences both being stereotyped as model minorities and facing microaggressions even when they are not strictly a minority group

within engineering represent salient discrimination experiences (Sue et al., 2007; Trytten, Lowe & Walden, 2012). We focused on but did not limit participation to early-career (second year) doctoral students to allow for participation in future research projects which flow from this initial qualitative project.

Participants who met our selection criteria from the Grads Project received an invitation to participate via email. The invitation described the interview as being about experiences in engineering doctoral education and included a link to a survey that included participation information and demographic survey items. Participants consented to participate at the end of the recruitment and demographic survey, received a consent document, and verbally consented to participation and recording of the interview at the beginning of their interview. Pseudonyms are used throughout to protect confidentiality. Participants were offered the opportunity to select a pseudonym; for those that declined, the authors randomly assigned pseudonyms from a list of the top 20 names in the U.S. This choice of assigning pseudonyms has the potential to promote names from the dominant culture while also masking aspects of individual identities but was necessary to ensure participant protection. Participants from 21 institutions across the country participated in video conferencing interviews. The first author's Institutional Review Board determined that participation was minimal risk and approved all procedures and materials used in the recruitment and interview.

The interview protocol developed for this project intentionally generated narratives about day-to-day doctoral student experiences and employed additional questions to seek elaborations about the people, activities, and places students engage within their doctoral program (Appendix 1). The interview began with day-to-day experiences to allow participants to describe their experiences without priming them to discuss discrimination or bias experiences. The team developed the protocol through an iterative process and pilot tested it with engineering doctoral students (Bahnsen, Cass & Wyer, 2019; Bahnsen, Wyer & Cass, 2019). The protocol engages participants in thinking about their daily activities, the people around them, and their relationships with those people in a day-to-day context. Participants described their typical day, and the interviewer asked follow-up questions to clarify relationships and to seek additional examples or narratives about the participant's experiences (e.g., Who is with you when you do [activity]?). The interviewer debriefed with the research team regularly throughout the pilot phase and periodically during the primary interview phase.

PARTICIPANTS

The participant pool included 30 ($n = 7$ pilot; $n = 23$ primary) doctoral engineering students. We included all the pilot participants as the data generated across all interviews was of value in highlighting the ruling relations of interpersonal relationships and was considered rich and thick when compared to the other interviews by the research team (Bahnsen, Cass & Wyer, 2019). This sample includes those who participated before we expanded the positionality of the interviewer in the introduction between the second and third pilot interviews. Pilot participants are labeled (P) to acknowledge the interview protocol's differences. On the recruitment survey, participants self-identified their gender identity by selecting from five options and a write-in option and race/ethnicity by selecting from eight options and a write-in option. Participants included 5 Asian women, 1 African American woman, 5 Hispanic/Latina/White-Hispanic women, 1 North African woman, 10 white women, 3 Asian men, 2 Hispanic/Latino men, 3 Middle Eastern men from across the United States (Table 1). While Asian students are typically counted as part of the majority group in STEM by governmental and educational organizations (e.g., NSF), the documented discriminatory experiences of Asian students necessitated their inclusion in our sample (e.g., Sue, 2007). In addition, our previous work has demonstrated the distinct experiences of white and Asian women (Perkins et al., 2020). In addition, participants indicated their engineering program (e.g., mechanical, civil), the year they started their PhD program, and if they had completed any PhD milestones (i.e., comprehensive exam and dissertation; Table 1). Fifteen identified as international students, five as bisexual, and all others as heterosexual, and 19 were in their second year, with others ranging from third to seventh. Participants represented twenty-one (21) universities which

ID	PSEUDONYM	GENDER	RACE/ ETHNICITY	INT'L	ENGINEERING PROGRAM	DEGREE MILESTONES*	YEAR
P1	Samantha	Female	Hispanic	No	Mechanical	None	Second
P2	Libby	Female	Asian	Yes	BioElectrical	None	Second
P3	Kamelia	Female	Latina	No	Biomedical	None	Second
P4	David	Male	Asian	Yes	Computer Science	Dissert.	Fourth
P5	Nicole	Female	White	No	Construction	None	Second
P6	Amanda	Female	White	Yes	Biomedical	Comp.	Third
P7	Heather	Female	Asian	Yes	Textile	Dissert.	Fourth
1	Rachel	Female	White	No	Mechanical	Comp.	Second
2	Melissa	Female	White	No	Nuclear	None	Second
3	Joshua	Male	Asian	Yes	Computer Engineering	Comp.	Second
4	Lauren	Female	White	No	Petroleum	None	Second
5	Dani	Female	Middle Eastern	Yes	Mechanical	None	Second
6	Megan	Female	White	No	Biomedical	None	Second
7	Susan	Female	White	No	Materials	Comp.	Second
8	John	Male	Asian	Yes	Electrical	Comp.	Second
9	Emmy	Female	Asian	Yes	Thermal	Comp.	Second
10	Christopher	Male	Middle Eastern	Yes	Civil	None	Second
11	Amber	Female	White	No	Chemical	None	Second
12	Vanessa	Female	Asian	No	Mechanical	None	Second
13	Sara	Female	Asian	Yes	Aerospace	Comp.	Second
14	Andrew	Male	Middle Eastern	Yes	Chemical	Comp.	Second
15	Daniel	Male	Hispanic/White	No	Biomedical	Dissert.	Fifth
16	Kelly	Female	White	No	Materials Science	Comp.	Second
17	Anthony	Male	Middle Eastern	Yes	Mechanical	Dissert.	Fifth
18	Caroline	Female	White	No	Environmental	None	Second
19	Mary	Female	Hispanic/White	Yes	Chemical	Comp.	Third
20	James	Male	Hispanic	No	Industrial	None	Fifth
21	Courtney	Female	Hispanic	Yes	Chemical	Dissert.	Fourth
22	Crystal	Female	African American	No	Chemical	Comp.	Sixth
23	Krista	Female	Hispanic	Yes	Chemical	None	First

Table 1 Participant Demographics.
 Notes: * None = no degree milestones beyond classwork were completed; Comp. = comprehensive exam completed; Dissert. = comprehensive exam and dissertation proposal completed.

were all R1 research-intensive universities, and the majority were predominantly white institutions (PWIs) with some minority serving institutions (MSIs). Seventeen (17) distinct engineering disciplines were represented (Table 1). Demographically, the sample does not represent the national engineering doctoral student population; instead, it reflects TUSs, focusing on women and men of color, and white women. Some demographic information is not connected to participants to protect anonymity.

POSITIONALITY

The research team includes experienced qualitative researchers, engineers, gender experts, STEM experts, and psychology researchers. The range and depth of expertise on the research team provides a rich base upon which to build this research study. The primary interviewer, analyst, and

first author has extensive interviewing experience, and studies equity and identity in STEM fields. He is a white, cisgender, gay man. The third author is a white, cisgender, senior feminist scholar committed to equity in higher education in STEM, and particularly in doctoral education. The second and fourth authors are both white males, with the fourth author identifying as gay, and working in engineering education with a significant focus on graduate education. These characteristics undoubtedly influenced the interviews and analysis, requiring significant attention to positionality from the whole research team throughout the research process. The composition of the research team situates our analysis as not of similar demographic background to the participants in our research. Our position then affords us some separation from the lived experience of participants while requiring attention to our different perspectives on engineering graduate education and, more broadly, on higher education practices.

Further, the team consulted with engineers and qualitative experts beyond those on the research team with a variety of backgrounds to promote an inclusive analysis process. Engineering educators assisted us in situating students' experiences in engineering, specifically assisting in disengaging from assumptions based on broader STEM higher education expectations. The team acknowledges that their background and experience naturally impact their contributions to this research project's completion. We assume that while we attempt to set aside existing knowledge about engineering graduate students' experiences, we cannot altogether remove ourselves from that knowledge. We approached the project open to new ideas during interviews and analysis that may or may not fit with our existing knowledge. The research team interrogated and challenged these preconceptions throughout the interview coding and data analysis process by articulating preconceived interpretations and challenging them with alternative interpretations.

ANALYSIS

The research team anonymized all unique identifiers in transcribed interviews. Transcripts were coded on the Dedoose platform by the research team (Dedoose, 2018). Codes were developed inductively, where codes were added for new phenomena as they occurred throughout the coding process. Interviews were coded for instances of discrimination, differential treatment, and other types of conflict shared by participants. The analysis team refined and edited codes as necessary. Phrases, sentences, and paragraphs were coded based on the content of the material. All interviews were coded by the first author and at least one other team member. The first three interviews coded by each team member were reviewed with the team to establish and confirm the consistency of the coding. The team met weekly for three months to discuss and review questions or concerns with coding.

Analysis using constant comparative techniques led to the development of themes useful in our descriptive qualitative analysis. Constant comparative analysis allowed researchers to investigate themes through an analysis of individual interview themes and comparison of those themes with other interviews (Boeije, 2002; Framt, 2013). Comparing interviews allowed the interviewers to discover similarities, generate categories, and identify patterns (Boeije, 2002; Tesch, 1990). Our analysis included fragmenting and connecting the texts (Boeije, 2002; Dey, 1993). Fragmenting identified distinct themes for each interview by breaking the text into distinct meaningful pieces outside of the interview context (Boeije, 2002). Connecting balanced fragmenting by refocusing analysis on the context of the text and the meaning within the broader interview (Boeiji, 2002; Sivesind, 1999).

Comparing and contrasting interviews formed the basis for categorization, phenomenon boundary setting, assigning text to categories, defining, and summarizing categories, and identifying evidence counter to the category (Boeije, 2002). Using modified steps identified by Boeije (2002) for constant comparative analyses, we first compared text within an interview. Then, a comparison of similar experiences between interviews.

Open coding allowed for codes to emerge from the texts. The first step involved categorization, label development, and code definitions for each part of the interviews. After the first step, provisional codes distilled from the interview contributed to an initial interpretation of the interview

and the beginning of the analysis process. Codes changed during the first step to be adapted when another interview text exhibited the code, while it expanded the definition of the code. This breach of a phenomenon boundary provided new examples and a better understanding of codes and categories of codes as required by new text.

In the second step, assigning texts to categories and comparing texts, codes, and categories between interviews allowed us to refine categories and codes further while identifying patterns across interviews. Simultaneously, it allowed for identifying text that discounts or contradicts patterns identified by the analysis team among other interviews requiring alteration or elimination of preliminary patterns. White women, women of color, and men of color (including Asian men) constituted three comparison groups. Comparing interviews within these groups assisted in connecting similar codes and categories across interviews to identify alignment across discrimination experiences. Connections and contradictions developed through research team meetings began our initial identification of themes.

Comparison between groups refined connections between codes and categories to inform themes as consistent or inconsistent across TUS groups. The group comparison step allowed us to question if groups who experienced discrimination shared in the codes, categories, and patterns describe their experiences. In the last step of comparison, material from each code, connections, and distinctions between codes helped identify a final set of themes and shared experiences in the data and assisted in identifying the consolidated themes in our findings. In addition, we compared participants' experiences and the corresponding codes to uncover the ruling relations in effect during the participants' experiences.

Finally, we considered how students' experiences reflected the ruling relations of doctoral engineering. Through theme comparison and additional emergent coding, ruling relations emerged from student experiences. We were able to identify ruling relations as they enabled or perpetuated discrimination within engineering doctoral education. In this step, we considered nationality in connection with race or ethnicity, however experiences specifically due to nationality are limited in the findings presented below and is grounds for future work. We focus our findings on students' experiences in their own words while following themes across interviews to describe the range of ruling relations engineering doctoral students experienced within the thematic scope.

FINDINGS

Participants indicated that discrimination experiences began early in doctoral education; originated from peers, advisors, and other faculty; and reinforced students' perceptions of themselves as insiders or outsiders in doctoral engineering programs. Participants defined their experiences to include their relationship to other people, the frequency of the experience, and the setting where the experience happened. However, the ruling relations embedded in the doctoral education system often were not directly recognized by students in their narratives, while still shaping participants' experiences. People, frequency, and setting defined experiences for students, while the ubiquitous ruling relations often remained hidden. Many participants seemed to remain unaware of the broader structural dynamics influencing everyday interactions while a few articulated structures that impacted their discrimination experiences.

Five themes illustrated ruling relations that shaped and are revealed by student experiences, and one superordinate theme that focuses on the interaction of and resistance to ruling relations in students' experiences. First, *Talking Matters* included a broad set of experiences relevant to the ruling relations that define how others spoke to students, experiences of talking to others, and how talking affected their ability to participate fully in engineering spaces. Second, *Faux Allies* highlight the ruling relations that enabled individuals who purport to be or are assumed to be allies but fall short of expectations in enacting allyship. The third theme, *Privileging Practices*, demonstrates practices supported by ruling relations that defined the preferential interpersonal and relational access and spaces of being a doctoral student. The fourth theme, *Affirmation*, identified experiences of ruling relation violations that enabled student participation in the doctoral education system or engaged students' engineering identification. In the fifth theme, *Self-Reflection*, some participants

discussed previous reflections on their experiences to understand their position in engineering, leading them to recognize or question some ruling relations.

Self-Reflection led to the superordinate theme: *Recognizing and Resisting Ruling Relations*. These accounts present participant narratives that describe the struggle and attention required to recognize the interpersonal sources of their experiences and resist the negative influences. The ruling relations found in this work reinforce each other and required work on the part of marginalized students to recognize and resist the ruling relations that harm or hinder their development as engineers. Further, the superordinate theme highlighted ruling relations that interweave to perpetuate the oppression of women and men of color and white women in engineering doctoral education.

1. TALKING MATTERS

Participant accounts revealed complex unspoken ruling relations that inform language usage, acceptable communication styles, the permissiveness of disrespect, and the meaningfulness in the tone of voice that reflect enactment of ruling relations defined and reinforced by the structure of doctoral education. While communication impacts all aspects of education, interactions with others represent some of the most striking and salient experiences that our participants shared during the interviews. Participants were aware of the pertinence of the quality and quantity of communication to their success as engineers. At the same time, they could see and hear the distinction between communication styles directed at them and others with variation based upon gender and race. One repeated experience outlined a ruling relation that enabled some people to talk down to others with little or no consequence. The repeated experience became an implicit expectation for participants in their interactions with other engineers.

Heather: He [Class Professor] would discuss complex math with the male students, then turn to us [two female students] and then dumb it down like we didn't understand when he was telling the male students. ... It made me question if engineering is just for men.

Feedback is essential to the development of doctoral students, and receiving it, or not, has a meaningful impact on students and their perceptions of their place within engineering. This ruling relation the occurs in interpersonal relationships highlights the necessity of feedback, and the importance of agency in who gets to define the tone, content, intention, and destructive or constructive content. Participants' consistently experienced feedback in ways that favored men and white people. Participants reported a range of feedback experiences from friendly feedback to an absence of feedback. In the first quote, Amanda discussed the difference in feedback quantity and quality from her advisor, which she attributed to a difference in interaction style for her compared to her male peers.

Amanda: He treated me differently, he never yelled at me in any way, like he yelled at the guys. He wouldn't get into discussions, or I would say arguments, with me, like, he would with others in the lab. I thought it was very clear I was treated differently.

In the next quote, Megan discussed her advisors' reaction to a request for more feedback and how important that interaction is for her progress.

Megan: He has given me more feedback [recently], and it's productive feedback. He would say, "Hey, there is something else you can do to make it better," and I really need the interaction and more feedback from my advisor and I technically have two advisors, right now, one of them is less interactive and doesn't really respond, but my primary advisor is really responsive.

Megan's need to request feedback contributes to a ruling relation other participants recognized that defines professional engineer communication styles as impersonal and unfriendly. Further, some participants recognized and excused unfriendly communication styles as a normal and necessary ruling relation for successful communication with engineers. The socialization into engineering

included this focus on professional communication as impersonal while deemphasizing any personal interaction in favor of measurable work outcomes as more valuable than the individuals' experience in education.

Lauren: It's OK. It's not like friendly or amiable, but it's very professional. And like when we communicate by email, she responds right away. And it's very efficient and a lot of stuff gets done. And she really drives us to do a lot of work and so we've like published several papers and done a lot of cool research.

In the classroom and labs, the ruling relations included norms and expectations for interactions embedded with messages of disrespect. In the following example, a participant recognized an inappropriate comment by a faculty member and its negative effect on her peers while denying impact on herself. We point this out to emphasize that students note sexist and racist comments while not necessarily recognizing the cumulative or indirect impact on their professionalization as engineers.

Rachel: One of my friends had done a problem very well and he [the professor] told him [peer] one day that he was going to be able to have a beautiful, blonde, cute secretary. He got in a lot of trouble. There were a lot of complaints to the department. It doesn't really bother me, but I can understand why it would bother other people.

The ruling relation that allowed disrespectful communication extended to disrespectful peer communication as well. The next examples of talking matters reflect how the students interpreted the messages of disrespect as perpetuating the expectation that they did not belong in engineering, which exhibits an underlying ruling relation for engineering to conform to white male expectations.

Megan: I went to office hours once; it was spring and I wore this summer dress. I show up and the TA looks at me and he's like "you know this is office hours for this computer science class." he treated me like I didn't know math, like I didn't know basic linear algebra. I was like ok, I'll pretend like that didn't happen, then I'll ask my question. The whole interaction was really not comfortable for me, the "oh you don't belong here" thing, which was kind of weird. things like that happen and they kind of eat away at you.

Throughout these examples, the way in which others talked to participants mattered to them and remained salient memories while demonstrating the norms and expectations of ruling relations in engineering. Students' accounts throughout the following sections echo the importance of talking matters and how the theme permeates interactions shaping the identity development of doctoral engineers.

2. FAUX ALLIES

The second theme identified from participants' interviews represents how students did not reliably find support from their advisers and peers, or how the support represents an unintentional insult cloaked as support. This theme exposes a ruling relation that allows peers, professors, and advisors to avoid supporting TUSs. The first quote is a description of her male principal investigator's demonstrated allyship and the struggle she had with male peers seeing themselves as allies but who were unable to recognize the disrespect she faced from a postdoc in their lab. The advisor pushed back on the ruling relation, while male peers failed at resisting the norm, and the postdoc reinforces the male norm ruling relation. These experiences revealed to her that she could not count on all allies equally to actively help her in negative experiences.

Sara: So there are some men who have been allies, but the majority of men I feel like – that I am friends with in this field, they acknowledge that these things are an issue if it comes up. But they don't have, sometimes, the social skills or the critical thinking skills in a situation, in real time, to analyze and understand that; hey, this postdoc was talking down to me.

For some participants, their advisor represented a prime source of support and advice: “we have good, open communication” (Daniel) and “he gives me a lot of advice” (John), while for others, advisors became a source of discouragement: “she shuts down my ideas” (Heather). These experiences highlight a ruling relation that allows advisors to determine the amount and quality of support and advice provided to advisees. The next example presents Crystal’s response to a series of unsupportive comments from her advisor. At a symposium, another attendee commented that Crystal was very talented, and Crystal’s advisor replied with a comment about Crystal’s experimental failure rate being high. Crystal received the comment as an unsupportive and discouraging, public rebuke of her research progress reflecting the advisor’s past race-based derogatory comments. The ruling relations inform Crystal’s interpretation and the advisor’s response to that interpretation – an assumption that advisors are allowed to make unsupportive and microaggressive comments with the burden of identifying and addressing problematic communication on students.

Crystal: I decided to talk to her about it ... that [derogatory] comment. And I asked her, “Why did you say that?” And she said, “Well, thank you for bringing this up to me. If you have any more issues, please bring them up in the future.” And that day that she told me that she brought that up because my project was hard.

Participants related experiences with their advisors that reflected the advisor’s research priorities rather than the students’ educational priorities. The interpersonal message reinforced a ruling relation in which the student’s needs are necessarily subservient to the advisor’s desires. The top-down power structure is reinforced and perpetuated in ways counter to the doctoral student’s development as an independent researcher.

The last quote in this theme presents an interaction with the interviewer. The interview revealed the participant’s experience with the expectation of sexism as a ruling relation in engineering. In her account, women are expected to perform non-engineering tasks that their male peers are not required to perform, creating additional burdens for female students.

Kamelia: So with my PIs, like with my bosses, I don’t feel like there’s an issue. I don’t think that they are [sigh] I don’t think “oh, they are sexist”. I would like to think that they are not.

Interviewer: Oh wait, accidental sexists?

Kamelia: [laugh] Yes, yes. Like who is going to order the coffee, or who is going to set the meeting, who is going to talk to everyone and let them know what’s going on, who is going to figure out where are we going to go? Like those jobs are all women’s jobs.

The unintentional or “accidental” sexism reflects society’s norms and ruling relations that position advisors as powerful figures and women as helpers. Further, the engineering ruling relation that normalizes women managing social interactions reflects a broader sexist society concept of women as caregivers rather than engineers.

3. PRIVILEGING PRACTICES

Some participants related the ways particular groups were favored, enacting ruling relations that reinforced a social hierarchy of positions for students. Often students described their buy-in and complicity in the structure of engineering by normalizing a structure from which they may eventually benefit. The ruling relation enacted here reflects the advisor’s powerful position to dictate the hierarchy of those around them, thereby influencing others’ interactions. The following examples demonstrate a keen awareness and tacit support of privileging practices that reflect ruling relations of hierarchy and privilege as appropriate or even necessary: first, for traditionally well-served students; second, for advanced students; and third, for students assigned the priority projects.

Sara: She [advisor] does treat people differently in her lab group. [The students who are getting ahead are] straight white men who come from some level of money and

privilege or at least upper middle class. To her [it's trivial to be] worried about your monthly stipend because you are busy paying off undergraduate loans. People have to explain to her that not everyone has these things handed to them.

In Sara's quote, she identifies her advisor's privileged financial position as contributing to perpetuating a norm for students to be well supported financially beyond graduate school stipends. This example highlights a ruling relation that assumes students receive financial support and come from privileged backgrounds before entering engineering.

Melissa recognized the privilege older students received when they were invited to her advisor's home to interact both with him and visiting speakers. The importance of social interaction and privileged access reflects a ruling relation that allows advisors to give an access advantage to some students and not others.

Melissa: Yeah [my advisor has] a better relationship with some of the older students ... some students have been invited to his house for dinner and small groups where there's been a speaker that he's entertained. He invites a few of the students to hang out with them.

Daniel discussed examples that illustrate another ruling relation that allows privileging practices to trickle down from advisors to favored doctoral students to other doctoral students. He described the impact a "good" project can have on students assigned to it compared to those left with less desirable projects.

Daniel: In some labs there is favoritism. You're not necessarily working on a project so that you can publish and get done with your dissertation. They have you doing media, like what I have my students help me with. You're the assistant to the [one] that's actually getting all the projects.

The ruling relations identified here highlight advisors' acceptance of creating or reinforcing a preference or hierarchy within their labs and research groups. The hierarchy too quickly becomes based on social relationships rather than ability and merit.

4. AFFIRMATION: COMBATING RULING RELATIONS

The affirmation theme is striking because participants' experiences represented situations in which students felt they could easily have been excluded but were included through the intentional actions of another. In these experiences, participants felt exceptionally valued and included, making the experience especially salient in the ways it diverged from the normal ruling relations. The experiences reported here illustrate the positive impact defying harmful ruling relations has on student experiences. Further, these examples demonstrate the potential for change in ruling relations – individuals can and do resist expectations of privilege and power to support those around them. These experiences supported students continued participation in engineering when the experience could easily have gone differently. Similarly, some participants reported that well-intentioned actors improved over time. These positive interactions left a lasting impression on students and actively supported their feelings of belonging and development as engineers. Affirmation experiences are examples of positive experiences with others conferring in-group status on participants by engaging in specific actions that recognized the student's place within engineering doctoral education.

Dani: For example, when my advisor introduced me as "she's the one you need to come to, if you need some regeneration [help calculating regeneration for a thermodynamics problem]." So, I feel valuable. And like I can do something others need.

Providing support with unambiguous public praise firmly communicates that the student belongs and is a valued member of the lab group counter to ruling relations that define the student as other or not belonging. In Mary's interview, she commented that she knew her advisor's support to starting her PhD was not normal for engineering. In these extracted accounts, she recognized

that the ruling relations supported male-dominated practices in engineering while acknowledging her advisor's transgression from those practices to support her.

Mary: I found out that I was pregnant when I was about to come back for my PhD, so I hadn't even started yet. So I called him and I said, "I'm pregnant." And he was very supportive. I arrived when I was six months pregnant. [So for] those last three months, I did a lot of lit reviews. Then, at the end of the semester, that's when my son was born, and then that's when the summer came. So we had agreed that I could take the summer off. Then, he hired a lab assistant to do my research [experiments] while I was breastfeeding as well.

Existing ruling relations support some students more than others. The affirmation theme demonstrates that ruling relations can be defied or altered to better support all students. However, many of the expectations currently set-in ruling relations require adjustment to eliminate expectations of conformation to a white male ideal to succeed.

5. SELF-REFLECTION: REFLECTING ON RULING RELATIONS

Participants with experiences of or who had witnessed discrimination and bias shared stories about how they had made sense of their experiences and how those experiences influenced their development as engineers. The reflection on experiences assisted participants in recognizing ruling relations and enabled meaning-making of their experiences both to understand the experience as discrimination or bias and to move beyond the expectations of others to develop as engineers. Some accepted they might be unfairly refused an advanced engineering degree if they spoke up or resisted the discrimination or accommodated negative experiences by internalizing them. These students questioned and intentionally considered their position and sense of belonging in the engineering field. Some self-reflection may support professional identity development and connect current experiences to future goals. However, when self-reflection is in response to identity-based discrimination, it revealed a ruling relation that adds an additional burden for TUSs to process experiences and integrate them into their engineering identities to persist.

For example, Emmy struggled to acclimate to a predominantly English-speaking environment with little support from peers and faculty. Her struggle reflects a ruling relation that assumes students can and requires students to work and socialize in a language which may not be their first language. With the high proportion of non-US students in engineering, English-language proficiency is a ruling relation that students may struggle with before they even arrive in graduate school.

Emmy: Last year when I arrived, my English is pretty bad, because in my country we don't speak English much. So, I have difficulty to make the communication, and there are many things I don't really understand. Then, once I start to understand better and be able to follow the conversation, then I feel like - I become more in and be part of the group more.

Other participants related self-reflections that helped them process their self-doubts and experiences of racism, sexism, and bias. These participants stepped out of their circumstance to recognize the discriminatory nature of the ruling relations they were experiencing and separate themselves from internalizing the experience. For instance, Courtney rationalized that she must be doing well enough (despite sexist comments from others) because she had not been removed from the program.

Courtney: My advisors would have kicked me out a long time ago. So, I just keep pushing. And you know, it's stressful because I have to fight with my head all the time, feeling bad ... But if still, they think I cannot make it, then it's okay because, I know I did my best.

Kamelia: They [sexism and racism] don't affect me on the daily or maybe I'm already so apathetic about the racism or sexism that exists. It's not like I don't want to talk about it. But it's so obvious of course, my name is [Kamelia's Latinx Last Name] so it's written on my forehead.

Crystal: And I just find that I realized that this life that I live, where everyone gave me the benefit of the doubt and saw good in me, is not here [engineering]. And that when people say that Black people need to work ten times as hard as everyone else, I never understood that until I went through it [in engineering]. ... I am more aware of the cultural biases that are ingrained in today's society.

Self-reflections illustrated students' abilities to recognize the ways ruling relations were being used against them. The mental and emotional effort required of students who experience discrimination, the resilience required to reflect on discrimination experiences, and continue in graduate school demonstrates an expectation that requiring TUSs to do this extra work is not only okay but is part of the design of the system.

6. RECOGNIZING AND RESISTING RULING RELATIONS

Our final set of quotes represent the superordinate theme of how students recognized the impact of discrimination and bias on their development as engineers. In these accounts, the ruling relations of engineering (Pawley, 2019) ensnared TUSs and increased the difficulties of performing the work necessary to continue in engineering doctoral education and be recognized as engineering professionals. In reflecting on her discrimination experiences in engineering Crystal stated, "I'm learning a lot of these unwritten rules on my own." Several of these accounts included multiple themes in combination in which a student was able to recognize the ways ruling relations limited their multi-dimensional identities and agency through messages of professional socialization that implicitly and explicitly restricted *who* can be an engineer and *what* engineering is at the doctoral level. Even while recognizing the rules required for success in engineering, some of our participants discussed how they resisted the rules. Many students covered multiple themes within one statement as they discussed experiences with racism and sexism. Below Krista, Katherine, and Sara discuss their experiences that reflect most, if not all, of our themes. The following examples demonstrate the interconnectedness experience of ruling relations and the impact they have on students, as well as the balance between accommodation and resistance.

Krista – Talking Matters and Privileging Practices

In the following extended quote, the ruling relations which empowered male students to request work from female peers and the expectation of a hierarchy in the lab members reinforced sexist norms for women. Krista provided an example of a male peer asking her to do work typically assigned to an undergraduate lab assistant. She wrestled with his request as reasonable in some instances, but less so for others through a hypothetical situation. In the end, she identified the pattern for this peer in asking female peers to do his work for him.

Interviewer: Give me an example of a task they would ask you to do that would normally be given to an undergrad.

Krista: Yeah, so stuff with [his] projects, like oh can you run like this assay, it's really easy. Or this just happened. [He asks], are you gonna be making particles this weekend, and I honestly don't know if I will be here this weekend. I might fly out for a funeral service... I probably won't be making particles this weekend. [He says] oh darn it because [we're] I'm going to [nearby city] for this event. So that means I would have to make particles for [him] because [he] don't have enough, while they're [going to] this event. I would never ask someone to do my research on the weekend while I'm out having a good time. It's just a respect thing.

Interviewer: Have you ever talked to somebody about that?

Krista: I talk to other people in the lab about it, and [they said] definitely don't do it. And at the beginning I would do the things because it was helping me learn or so I thought, but they were tasks that don't really contribute much to my growth. I think this person has tried to get other people to do tasks like this. Specifically, females.

The interaction demonstrated the ruling relations that support power-laden hierarchical thinking. For instance, the ways that talking matters in interactions between peers in the form of what favors are appropriate to ask for, in what situations, and also of whom they should be asked. The interconnection also demonstrated the privileging of positions within the lab, as in some tasks are undergraduate tasks or tasks to be pawned off on others when possible. Further, Krista identifies this interconnection when she connects her male peer asking female peers to do this lower-level work as a pattern.

KATHERINE: TALKING MATTERS, FAUX ALLIES, AND PRIVILEGING PRACTICES

Katherine described her relationship with her male lab mates as poor and shared her experience trying to work with them, but in the end, changing her office space to reduce her interactions with them. Her narrative reflects and connects the ruling relations in the themes of Talking Matters, Faux Allies, and Privileging Practices. By asking her to do domestic tasks and menial lab work, her lab mates engaged in talking down to her and demonstrated they did not see her as an equal. Later in the quote, Katherine discussed involving her advisor in setting ground rules for the lab to try to address inappropriate behavior. The advisor and Katherine both see these ground rules as enabling Katherine; however, we see a missed opportunity for the advisor to address the lab mates' inappropriate behavior on behalf of Katherine, demonstrating both a Faux Ally and a privileging of the male advisor and male lab mates' positions within the lab. Their position is further privileged when Katherine is the one to change office spaces to distance herself from the inappropriate lab mates physically.

Katherine: I have a poor relationship with my lab mates. I tried very hard to make it work the first year and then I realized that being around the lab mates is draining for me because they often had me do work for them. So even though I have been able to stand up for myself, I still don't like it, so I moved offices to get away from them. And so I do not interact with them very much if at all and my friends in the office are from other labs at my institution.

Interviewer: What happened with your lab mates that you don't get along with them?

Katherine: Well, I have **two lab mates and so I found myself often being asked to cook for them, which I found to be wildly inappropriate, and to mend pants**. I'm not kidding you, these things happened! And then also in the lab they expected me to be doing the general lab things like taking out the trash and like making sure that we pass our inspections. So that drove me up the wall. And so, I learned how to say, "no that's inappropriate." But every time I say that, it doesn't feel empowering to me, it feels really horrible like I'm being a horrible person which I know is not true. **So, I stopped going to the office to avoid them, to avoid interacting with them. And then that led up to me switching offices. I'm much happier in my new office. (Emphasis Added)**

Interviewer: Do you still share lab space with them like experimental lab space?

Katherine: Yes, yes, but we have also set some more boundaries there. So we had some issues. I guess I should clarify, my adviser just moved to our institution. He's not a first-time adviser, but he is building a new lab here. And I arrived at the same time he arrived. So getting all of the lab protocol setup was – I mean is contentious and difficult. So we share lab space quite well now because we had set boundaries like this stuff is my stuff and that – there's your stuff and don't put stuff on my shelf or here or here. But when we didn't have that, there's a lot of – there were a lot of issues. But yeah, sharing lab space is fine because usually we're just working on our individual things.

Sara: Talking Matters, Faux Allies, Privileging Practices, and Self-Reflection

Sara related her impressions of experiences involving her male advisor, a male postdoc, and male doctoral student peers and the ruling relations which required her to engage and educate these males while they are not required to educate themselves. In her narrative, she demonstrated self-reflection in her interactions with all three sets of people while pointing out their privileged

positions as males and within the lab hierarchy. The interactions with her advisor, postdoc, and peers demonstrate the variety of ways individuals engage in talking that matters.

Sara: My mentor, I know has been supportive in the meeting when the post doc was talking down to me, but there'll be other graduate students or post docs who are my friends outside of work and they're male colleagues. But to them it sort of blows over their head and I'll just say to them, "Did you realize this post doc was talking down to me?" And it requires a very long conversation to explain it. And then they'll say, "Well, I'm sure he didn't mean it that way." And I'm like, "No, this is a consistent pattern in every interaction I have had with him and every interaction I have observed of him with a female."

The time and emotional labor invested in educating her peers and continued interactions with sexist behaviors reflect a ruling relation that allows sexist behavior from men while requiring additional effort from women. The ruling relation reflects an eternal problem of oppressed people – oppressed groups are required to educate their oppressors.

FINDINGS SUMMARY

The accounts of participants in our study are filled with stories that are full of underlying racist and sexist dynamics within the ruling relations that systematically privilege some students over others. These encounters represent ruling relations that form a social fabric of exclusionary practices and inclusionary privileges. For an underserved doctoral student, the striving-to-belong (to be an in-group member) requires work that white male students do not have to do. Students have vivid memories of being dismissed, disregarded, disrespected, and subjected to the appropriation of their labor to benefit white male peers in the lab. Even a mentor, who is expected to be supportive, can be a "faux ally," by providing too little praise too late, without apologizing. In our study, the constant, pervasive, and variability of insults took a toll on traditionally underserved doctoral students' sense of well-being as they had to be alert to them to protect their identities as innovative and skilled emerging talents.

Traditionally underserved engineering doctoral students often do not recognize the discriminatory aspects of ruling relations embedded in organizational, institutional, and structural practices that required them to attend to being accepted and being discounted (Smith, 1987; Smith, 1999). In our study, a few doctoral students recognized the discriminatory aspects of ruling relations in which they worked and relayed experiences that jarred them out of complacency with and conformity to the expectations. Some experiences were so egregious, appalling, or blatantly offensive that the experience prompted self-reflection and recognition of power dynamics that informed daily interactions. Some participants took this step as an internal reflection upon experiences to understand for themselves what the experiences meant, as reflected in our Self-Reflections section. Further, a few students reflected on their experiences and described the experiences, including some critique of the system or power dynamics involved in the Recognizing and Resisting Ruling Relations section. Participants' encounters describe the sustained and reproduced discriminatory set of oppressive ruling relations in engineering doctoral education. Nonetheless, most participants remained entrenched in the system of power and privilege, unable or unwilling to directly acknowledge or openly challenge the ruling relations or institutional structures that supported and perpetuated their negative experiences.

DISCUSSION

Doctoral students shared narratives of deep and nuanced experiences of discrimination and bias in their daily interactions that highlighted ruling relations reflecting a white male-dominated norm in engineering. Our analysis identifies aspects of engineering doctoral education that may not be recognized as discrimination by many in the engineering community. By identifying the themes presented here and identifying key practical implications and takeaways, we hope engineering educators will be able to consider their own actions and interpersonal relationships as

reflected by this work. Through each of the themes, a detailed examination of these experiences displayed the often-insidious ways discrimination manifested for students. Though these themes resonate with work focused on structural or sociocultural aspects of discrimination and bias, which informed our interpretations (e.g., Burt, Williams & Smith, 2018; Chubin, May & Baboo, 2005; Pawley, 2019; Smith, 1987; Smith, 1999; Truong, Museus & McGuire, 2016), our themes have emerged from students' accounts of day-to-day interactions. By this, we mean that students' recollections included what people said (or did not say), whom they could trust, how they saw and navigated through the surrounding and normalized ruling relations, what they thought about themselves amid these relations, experiences that contributed to belonging and affirmation, and how they balanced their desire to be a privileged insider with limited attention to the erasures and accommodations that would be required of them. This insight can be summarized by saying that engineering doctoral students who are traditionally underserved notice what is happening around them and to them. They take special note of incidents that alert them to hurtful messages and those who deliver harmful messages. This ever-present attention to messages may well be embedded in the institutional structures and ruling relations of doctoral education more generally. However, we argue that the attention required is especially salient for traditionally underserved doctoral students in engineering.

The experiences described by our participants point to ways policy and practice have failed to make engineering doctoral education equitable (Bahnon et al., 2021; Bancroft, 2018; Burt, Williams & Smith, 2018; Burt, Williams & Palmer, 2019; McGee, 2016; McGee & Martin, 2011; Perkins et al., 2020; Ramirez, 2014). The ruling relations of doctoral education function as intended to support traditional students; while limiting success and generating differential educational experiences for TUSs (Pawley, 2019). The doctoral training experience often builds upon the traditional apprenticeship model with assumptions of a primary advisor leading and guiding a student through the doctoral project (Bégin & Gerard, 2013; Gittings, 2018; NASEM, 2018; Perkins et al., 2020; Ro & Loya, 2015; Verdín, Godwin & Morazes, 2015). In our interviews, we found that this assumption is no longer appropriate. Students often worked with peers and faculty members, which increased both the opportunities for success and complicated the relationship power dynamics at play. The interpersonal relationships required by doctoral education too often ignore or devalue the social and personal identities of students (Bancroft, 2018; Burt, Williams & Smith, 2018; Dutta, 2015; Martin, Simmons & Yu, 2013).

Throughout the relationships, encounters, and spaces described by our participants, the system of ruling relations did not always support their identities and development as engineers. The lack of support for social and personal identities is further complicated when balancing professional development roles as researchers, teachers, and learners further complicated professional identity development (Kajfez & McNair, 2014). Institutional policy and practice were not sufficient or enforced to address the day-to-day interactions that students described, experienced, and remembered. Transformation at the institutional level is required to adequately address the experiences we have described (Gumpertz et al., 2019). To adequately address these power differentials, the engineering community needs to reorganize doctoral education to alter the ruling relations to serve and support students equitably.

We cannot overstate the importance of constructive and supportive communication between advisors, mentors, and graduate students (Artiles & Matusovich, 2020; Bahnon et al., 2021; Burt, Williams & Palmer, 2019; Miles, Brockman & Naphan-Kingery, 2020; NASEM, 2018). Our participants shared the significant mental and emotional resources absorbed by the interaction with advisors who were not seen as allies because of previous communications and lack of affirmations. "Working with graduate students requires sensitivity, empathy, and a recognition that they are adults with agency over their own career trajectories. Additionally, once graduate students enter graduate programs, faculty need to work to support the development and maintenance of their students' identities" (Berdanier, Whitehair, Kirn & Satterfield, 2020, p. 142). Further, the investigations and reports of these interactions should provide advisors and graduate students examples to discuss and adjust behaviors to better support graduate students (Berdanier et al., 2020).

Similarly, the importance of peer relationships and interactions remains a salient and meaningful source of negative and positive application of engineering's ruling relations. Research peers' relationships support engineer identity development (Bahnon et al., 2019; Crede & Borrego, 2012; Perkins et al., 2018b). Hierarchies define and apply ruling relations inequitably to students across interactions, even those that typically assist in educational or research objectives (Burt, 2017). However, peer support provides an opportunity for affirmation between peers who perhaps have had similar discrimination and bias experiences.

We also observed the immense dedication, resilience, and resistance required of our participants to continue their engineering doctoral education. From those that asked for what they needed to those who changed research labs (Bahnon, Wyer & Cass, 2019), participants demonstrated their ability to perform more work than their peers to succeed. When oppressed by unfair and discriminatory ruling relations, additional mental and emotional labor was required for TUSs to succeed, as represented by our superordinate theme.

PRACTICAL IMPLICATIONS

The themes found in our data indicated critical ways altered ruling relations could benefit TUSs. Updating norms for engineering communities to define student positions with equal terms, situated within groups of real allies without privileged positions could assist in altering ruling relations that are assumed to be a normal part of doctoral education but that disadvantage TUSs. These changes could alter the experience of engineering doctoral education and could provide support for the development of all students. Here we highlight key takeaways and provide some practical suggestions, questions, and ideas for advisors and other leadership to engage in recognizing and resisting ruling relations in engineering doctoral education. TUSs cannot be responsible for deconstructing and rebuilding the system alone – those with authority should take the negative experiences of TUSs seriously and take action to change the system, assumptions, and norms that perpetuate discriminatory ruling relations.

The first key takeaway focuses on the need for, constructive communication training needs to be integrated into training for doctoral students and faculty. Expanded training for faculty and students alike that discourages talking down, teaches positive mentorship techniques, engages strengths-based evaluations, and models constructive communication patterns could alleviate issues identified in our Talking Matters theme (Bilen-Green, 2015; Cross et al., 2021; Long & Mejia, 2016; Nieto, 2018; Pietri et al., 2019). Addressing *Talking Matters* requires setting aside assumptions about appropriate communication and real reflection on how communication happens within engineering doctoral programs, classrooms, and laboratories. For instance, responding to Sara's experience of being talked down to by a postdoctoral fellow, could have been aided by the advisor taking action at multiple levels. Addressing the postdoc directly is a first step; however, when the behavior is repeated additional reflection and action are required. Advisors should consider why bad behavior is occurring in their lab with real reflection on how the advisor interacts with everyone else in the lab. Some self-reflection questions could include, "Am I exhibiting this behavior when I speak to students (women, men of color or women of color)?" or "Who else in my lab (program, department, or college) demonstrates this behavior in a way that implies it is acceptable?" Advisors should consider that if it happens when the advisor is present, "Is it worse when the advisor is not present?" The answers to these questions can assist in identifying how the ruling relations of communication in engineering are negatively shaping the experiences of TUSs.

The next takeaway emphasizes the need to change current communication practices in the engineering community. This requires disrupting the negative communication ruling relations by the whole lab, possibly requiring training or information about being an ally to TUSs. For instance, advisors and lab members could participate in a positive communication workshop or interpersonal communication skills training. Finally, advisors should take time to build the skills necessary to talk to their TUS about these experiences. Developing these skills will assist advisors in creating an environment where TUSs feel welcome and comfortable expressing their concerns and experiences of discrimination. An open environment engages TUSs and could allow advisors

to better understand the frequency, intensity, and consequences of discrimination experiences for their TUS lab members.

Similarly, another key takeaway focuses on the need for allyship or cultural awareness training, combined with interpersonal communication skills to help advisors and students avoid the experiences described in *Faux Allies*. Students often lack access to equity, diversity, and inclusion training (Perez et al., 2019). A welcoming environment that supports a diverse group of students is essential to disrupting ruling relations about who belongs in engineering. Allyship training can help individuals identify behaviors that they may think are supportive but are perceived as unsupportive or ingenuine by others. Rewriting the ruling relations about who is expected to demonstrate allyship and how allyship is enacted benefits all students, deepening a supportive environment for all students to thrive.

Part of effective allyship is in developing and maintaining antiracist and antisexist engineering communities. Long III (2020) lists 20 actions for anti-racist action in engineering education with a focus on undergraduate education. These actions are just as necessary for doctoral education: for instance, revising doctoral curriculums to celebrate Black engineers and theorists (Long, 2020). Limited research has begun the work of integrating social justice, but much more is needed (Vargas-Ordaz & Haynes, 2020; Foster et al., 2019). Action to generate and support allyship alone is not enough. As Harden and Harden-Moore (2017) argue, allyship must result in action. Marginalized groups need accomplices who act in antisexist and antiracist work to truly move the burden of change away from already oppressed and burdened groups.

A key takeaway for advisors focuses on the need for critical self-reflection. Leaders, particularly advisors, should critically consider how they engage *Privileging Practices*. Some privileging is intended to be rewarding, such as celebrating a publication or passed exam, recognizing advanced students' skills and experience. However, these practices are easy to distribute unevenly, leading to inequality within the lab. For example, advisors should consider how social events engage some students and not others while attempting to understand the reasons behind differential engagement. Some students may not be comfortable going to a bar or private home after hours with coworkers and their boss – how can celebrations occur without alienating some students? Some simple solutions would be to celebrate during working hours, on campus, when all lab members are expected to be available.

Advisors should also critically assess how privilege contributes to the hierarchy within the lab setting. What is appropriate for advanced students to ask new students to do? How much (if any) authority should advanced students have over other lab members? Perhaps some authority is appropriate – training on specific equipment, safety issues, and experience with experiments may necessitate some hierarchy and authority within the lab in the advisor's absence. However, these expectations should be clearly defined, and it is the advisor's responsibility to ensure advanced students do not abuse their authority. Defining expectations mitigates the unspoken expectations and assumptions of ruling relations. Doctoral students could contribute to identifying what aspects of the power dynamics are appropriate and where power is misused within the lab. Open, supportive environments are necessary for students to confront inequitable power structures in which they operate.

Two aspects of *Affirmation* can assist in deconstructing ruling relations. First, advisors should consider who receives affirmation and how affirmation is communicated to students. Participants discussed how meaningful affirmation was to their continued success. Advisors consistently articulating their positive beliefs about students' abilities, progress, and potential can dramatically improve the experience of TUSs. Second, creating affirmation as a ruling relation within the open, welcoming lab community will encourage peers to support each other and strengthen feelings of belongingness, particularly for TUSs who may not receive these messages from others.

Some students described the ways they do much of the work described in these implications daily as part of their survival in an oppressive system. Others should recognize the time, effort, and mental health implications that grow out of *Self-Reflection* on discrimination experiences and oppressive ruling relations. Training and creating space for engineers to use self-reflection

techniques to meaningfully engage in viewing their social and personal identities in their work as engineers could alter ruling relation assumptions of the idealized engineer to foster an open, welcoming, and supportive engineering community. If advisors and more students participate in self-reflection on their behavior, the assumptions, norms, and expectations that perpetuate inequity and oppression, the engineering community can benefit from improved communication and open and welcoming environments that encourage and support all people in participating and succeeding in engineering. The reflection on experiences assisted participants in meaning-making of their experiences both to understand the experience as discrimination or bias and to move beyond the expectations of others in their identity development.

LIMITATIONS AND FUTURE WORK

This study's value lies in drawing attention to the daily practices that shape TUSs' experiences in doctoral engineering. Our themes emerged from interviews with 30 students who agreed to participate. Their accounts (and our findings) are thus defined by their experiences and are not necessarily generalizable to all traditionally underrepresented engineering students. However, the results provide insight into the experiences of some TUSs in engineering doctoral education. We did not explore how sexual identities could have been implicated in distinctions between insider-outsider identities. Similarly, non-binary and gender non-conforming people are not present in this work. Nor did we ask a comprehensive set of questions to explore students' interest in (or knowledge about) their department or university's equity and inclusion policies or the availability of training opportunities. In most examples, we do not know if the faculty and peers in their accounts cared about or repaired the microaggressions or subtle insults reported in the accounts. We did not explore the complicated and extensive networks of biases promoted by cross-national and international histories and customs. However, the narratives do capture unique (and yet not unprecedented) insights about engineering doctoral education, and they are grounded in the voices of our participants. They offer powerful testimony that suggests future research areas at the individual, interactional, and institutional levels.

The narratives and themes may be useful in generating discussion among faculty, administrators, and doctoral students generally. Specific underserved racial and ethnic minorities were not well represented in this data and may face unique experiences based on individuals' treatment from a specific background. Additional investigation is needed to uncover the unique experiences of discrimination students experience based on intersecting social identities, including marginalized racial and ethnic groups and women, but also gender minorities, sexuality minorities, international students, first-generation students, students living with disabilities, and students from various socioeconomic backgrounds in engineering doctoral education.

The intersections of oppression described by our participants were pervasive and encompassed all these TUS groups. In this work, we considered the impacts of gender and race/ethnicity intersections on discrimination and bias experiences. However, the multitude of intersecting identities requires more detailed exploration and targeted requirements to fully explore the intersections and individuality of underserved student identities. Our results present TUS voices and experiences in engineering doctoral program, however work focusing on specific identity driven experiences must continue to generate change in the educational system.

CONCLUSION

This study offers perspectives that can help engineering doctoral education meet its ethical and professional commitments to cultivating diverse generations of engineers. There are three primary ways findings from our study support critiques of the ruling relations enacted in engineering: (1) that engineering doctoral students who are traditionally underserved notice what is happening around them and to them; (2) that these encounters represent ruling relations that form a social fabric of exclusionary practices and inclusionary privileges; and (3) that the discrimination revealed by the encounters sustain and reproduce that set of oppressive ruling relations. Taken together, our findings suggest opportunities for change in which engineering doctoral education

leadership can disrupt and challenge the habits and behaviors that permit and sustain daily insults within peer-to-peer and faculty-to-student interactions. Similarly, faculty using their authority to address interpersonal problems as they arise is critical to students experiencing harmful ruling relations. Interpersonal interactions and relationships are enormously complicated and guided by the unspoken ruling relations of engineering. Too often, social identities are seen as, at best, a distraction and, at worst, irrelevant altogether. However, social identities play a large part in how individuals perceive and experience the active ruling relations in their educational environment. If students are forced to endure the continued burden of ruling relations, they will feel as if they do not belong and shut out of engineering.

APPENDIX 1

FINAL INTERVIEW PROTOCOL

Interviewer: Thank you for agreeing to participate in our research project. Before we begin, I would like to confirm you are willing to participate and have our conversation video and audio recorded. You can withdraw from the research at any time, simply by telling me you would like to stop the interview. The recordings will be transcribed and analyzed for themes. Your privacy is very important to us, and we will protect your confidentiality by using password protected files and pseudonyms. In addition, please refrain from naming specific people and places to protect third party identities as well as your own. If you do, we will use pseudonyms for everything. Do you agree to participate and be recorded? We will not use your name or university in any publication of the research. Would you like to choose a pseudonym for yourself and your university?

Let's begin our conversation. First, let me introduce myself. My name is (NAME) and I am a student at North Carolina State University in Applied Social and Community Psychology. I am interested in how students experience graduate education and how those experiences influence their identities. My interest in STEM graduate education grew from my husband's experiences as a Uruguayan graduate student in cell biology. Do you have any questions for me before I get to my questions?

Engineering Graduate school

I'd like to start by getting a picture of what it's like for you to be a graduate student in engineering day-to-day. Can you start by telling me what it's like being a graduate student in engineering?

- What does a typical day look like for you, what kinds of activities are you engaged in?
- Which of those activities are meaningful for you and how?
- Who is with you when you do [activity]?
- How do you relate to them or not relate to them?
- How do you feel when doing those activities?
- Who is in the lab and your classes with you?
- What is your relationship like with that person? (How do you interact?)
- How does being in graduate school make you feel?

(Identity) We have talked about your graduate school experiences. I am also curious about how you think about engineers. What encouraged you to become an engineer?

1. What is your favorite activity when you are not being a graduate student? How would you introduce yourself to a new person in that activity? In a different scenario, how would you describe yourself, if we were to meet at a party of graduate students, how would you introduce yourself?
 - a. How would you introduce yourself to a new engineering faculty member?
 - Probe on engineer identity: What does it mean to you to be an engineer?
 - Probes: What experiences let you to feel like an engineer?
 - How did (experiences/people from section 1) influence your feeling like an engineer?
 - Bias – experiences not discussed previously
 - Thinking about the demographic survey you completed, what demographic categories are most meaningful to you?

2. Can you give me an example of a time in engineering grad school when you felt your ideas or perspectives were/weren't especially encouraged?
3. Probe for weren't encouraged: Did you speak to anyone about your experience? (Advisor, Peers, program or department staff, counselors?) Who and how did that conversation go?
4. Have you found your program to treat all students equally? Why or Why not?
5. Have you found engineering as a field to be supportive of all students? Why or Why not?
6. What about being supportive of students like you?
7. Are there things your university could do to be more supportive?
 - a. What about your program?
 - b. What about your advisor?
8. How did your program influence how you think of yourself as an engineer?
9. How did your engineering college or university influence how you think of yourself as an engineer?
10. How did these experiences influence your feelings of being an engineer?

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The authors have no competing interests to declare.

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REFERENCES

- Artiles, M. S., & Matusovich, H. M.** (2020). Examining doctoral degree attrition rates: Using expectancy-value theory to compare student values and faculty supports. *International Journal of Engineering Education*, 36(3), 1071–1081. https://www.ijee.ie/latestissues/Vol36-3/22_ijee3935.pdf
- Bahnson, M., Cass, C., & Wyer, M.** (2019) Student Poster “Interview Protocol Development to Explore Experienced Bias in Engineering Graduate Students”. *Presentation at 31st Association for Psychological Science Annual Convention*, May 23–26, 2019, Washington, DC, USA.
- Bahnson, M., Perkins, H., Tsugawa, M., Satterfield, D., Parker, M., Cass, C., & Kirn, A.** (2021). Inequity in graduate engineering identity: Disciplinary differences and opportunity structures. *Journal of Engineering Education*, (October 2019), 949–976. DOI: <https://doi.org/10.1002/jee.20427>
- Bancroft, S. F.** (2018). Toward a critical theory of science, technology, engineering, and mathematics doctoral persistence: Critical capital theory. *Science Education*, 102(6), 1319–1335. DOI: <https://doi.org/10.1002/sce.21474>
- Banda, R. M.** (2012). *Perceptions of Social Support Networks and Climate in the Persistence of Latinas Pursuing an Undergraduate Engineering Degree*. A Dissertation by ROSA MARIA BANDA Submitted to the Office of Graduate Studies of Texas A & M University. <https://ezaccess.libraries.psu.edu/login?url=https://www.proquest.com/dissertations-theses/perceptions-social-support-networks-climate/docview/1319256064/se-2?accountid=13158>

- Bégin, C., & Gérard, L.** (2013). The role of supervisors in light of the experience of doctoral students. *Policy Futures in Education*, 11(3), 267–276. DOI: <https://doi.org/10.2304/pfie.2013.11.3.267>
- Berdanier, C. G. P., Whitehair, C., Kirn, A., & Satterfield, D.** (2020). Analysis of social media forums to elicit narratives of graduate engineering student attrition. *Journal of Engineering Education*, 109(1), 125–147. DOI: <https://doi.org/10.1002/jee.20299>
- Bilen-Green, C., Carpenter, J., Doore, S., Green, R., Horton, K., Jellison, K., ... O'Neal, D. P.** (2015). Implementation of advocates and allies programs to support and promote gender equity in academia. 2015 ASEE Annual Conference & Exposition. DOI: <https://doi.org/10.18260/p.24242>
- Boeije, H.** (2002). A purposeful approach to the constant comparative method. *Quality & Quantity*, 36(4), 391–409. DOI: <https://doi.org/10.1023/A:1020909529486>
- Burt, B. A.** (2017). Learning competencies through engineering research group experiences. *Studies in Graduate and Postdoctoral Education*, 8(1), 48–64. DOI: <https://doi.org/10.1108/SGPE-05-2017-019>
- Burt, B. A., McKen, A., Burkhart, J., Hormell, J., & Knight, A.** (2019b). Black men in engineering graduate education: Experiencing racial microaggressions within the advisor–advisee relationship. *The Journal of Negro Education*, 88(4), 493. DOI: <https://doi.org/10.7709/jnegroeducation.88.4.0493>
- Burt, B. A., Williams, K. L., & Palmer, G. J. M.** (2019a). It takes a village: The role of emic and etic adaptive strengths in the persistence of Black men in engineering graduate programs. *American Educational Research Journal*, 56(1), 39–74. DOI: <https://doi.org/10.3102/0002831218789595>
- Burt, B. A., Williams, K. L., & Smith, W. A.** (2018). Into the storm: Ecological and sociological impediments to Black males' persistence in engineering graduate programs. *American Educational Research Journal*, 55(5), 965–1006. DOI: <https://doi.org/10.3102/0002831218763587>
- Cass, C., Kirn, A., Tsugawa-Nieves, M., Perkins, H., Chestnut, J., Briggs, D., & Miller, B.** (2018). Improving performance and retention of engineering graduate students through motivation and identity formation. 2018 ASEE Annual Conference & Exposition. DOI: <https://doi.org/10.18260/1-2--27798>
- Chubin, D. E., May, G. S., & Babco, E.** (2005). Diversifying the engineering workforce. *Journal of Engineering Education*, 94(1), 73–86. DOI: <https://doi.org/10.1002/j.2168-9830.2005.tb00830.x>
- Crede, E., & Borrego, M.** (2012). Learning in graduate engineering research groups of various sizes. *Journal of Engineering Education*, 101(3), 565–589. DOI: <https://doi.org/10.1002/j.2168-9830.2012.tb00062.x>
- Cross, K. J., Mamaril, N., Johnson-Glauch, N., & Herman, G.** (2021). Building cultures of collaboration that promote instructional change. *Studies in Engineering Education*, 2(2), 1–18. DOI: <http://doi.org/10.21061/see.48>
- Daumeyer, N. M., Onyeador, I. N., Brown, X., & Richeson, J. A.** (2019). Consequences of attributing discrimination to implicit vs. explicit bias. *Journal of Experimental Social Psychology*, 84(April), 103812. DOI: <https://doi.org/10.1016/j.jesp.2019.04.010>
- Dedoose.** (2018). Version 8.0.35, web application for managing, analyzing, and presenting qualitative and mixed method research data. Los Angeles, CA: SocioCultural Research Consultants, LLC. www.dedoose.com
- Dey, I.** (1993). *Qualitative Data Analysis. A User-Friendly Guide for Social Scientists*. London & New York: Routledge.
- Dryburgh, H.** (1999). Work hard, play hard: Women and professionalization in engineering – Adapting to the culture. *Gender and Society*, 13(5), 664–682. <http://www.jstor.org/stable/190328>. DOI: <https://doi.org/10.1177/089124399013005006>
- Dutta, D.** (2015). Sustaining the pipeline: Experiences of international female engineers in U.S. graduate programs. *Journal of Engineering Education*, 104(3), 326–344. DOI: <https://doi.org/10.1002/jee.20077>
- Foster, E., Karlin, J., Riley, D. M., & Quiles-Ramos, S.** (2019). Seeding a strategic campaign to address root causes of inequity in engineering education. *CoNECD 2019 – Collaborative Network for Engineering and Computing Diversity*. <https://strategy.asee.org/31789>
- Framt, S. M.** (2013). The constant comparative analysis method outside of grounded theory. *The Qualitative Report*, 18(1), 1–25. Retrieved from <http://www.nova.edu/ssss/QR/QR18/fram1.pdf>
- Frehill, L. M.** (2004). The gendered construction of the engineering profession in the United States, 1893–1920. *Men and Masculinities*, 6(4), 383–403. DOI: <https://doi.org/10.1177/1097184X03260963>
- Gearing, R. E.** (2004). Bracketing in research: A typology. *Qualitative Health Research*, 14(10), 1429–1452. DOI: <https://doi.org/10.1177/1049732304270394>
- Gittings, G., Bergman, M., Shuck, B., & Rose, K.** (2018). The impact of student attributes and program characteristics on doctoral degree completion. *New Horizons in Adult Education & Human Resource Development*, 30(3), 3–22. DOI: <https://doi.org/10.1002/nha3.20220>
- Green, D. O., Creswell, J. W., Shope, R. J., & Clark, V. L. P.** (2007). Grounded theory and racial/ethnic diversity. In A. Bryant & K. Charmaz (Eds.), *The SAGE handbook of grounded theory* (pp. 472–492). Thousand Oaks, CA: SAGE Publications. DOI: <https://doi.org/10.4135/9781848607941.n22>
- Gumpertz, M., Brent, R., Campbell, C. D., Grasso, M., Huet, Y. M., & Schimmel, K. A.** (2019). An institutional transformation model to increase minority STEM doctoral student success. *CoNECD 2019 – Collaborative Network for Engineering and Computing Diversity*. Washington, DC.

- Hall, W. M., Schmader, T., & Croft, E. (2015). Engineering exchanges: Daily social identity threat predicts burnout among female engineers. *Social Psychological and Personality Science*, 6(5), 528–534. DOI: <https://doi.org/10.1177/1948550615572637>
- Hanson, S. L. (1996). *Lost talent: Women in the sciences*. Philadelphia: Temple University Press.
- Harden, B. Y. K., & Harden-moore, T. A. I. (2018). Moving from ally to accomplice: how far are you willing to go to disrupt racism in the workplace. *Diverse Issues in Higher Education*, 36(2), 32. <https://www.diverseeducation.com/opinion/article/15104148/moving-from-ally-to-accomplice-how-far-are-you-willing-to-go-to-disrupt-racism-in-the-workplace>
- Hesse-Biber, S. N. (2017). *The practice of qualitative research*, 3rd edition. Los Angeles: SAGE.
- Kajfez, R. L., & McNair, L. D. (2014). Graduate Student Identity: A Balancing Act between Roles. 2017 ASEE Annual Conference & Exposition. DOI: <https://doi.org/10.18260/1-2--20543>
- London, B., Rosenthal, L., Levy, S. R., & Lobel, M. (2011). The influences of perceived identity compatibility and social support on women in nontraditional fields during the college transition. *Basic and Applied Social Psychology*, 33, 304–2011. DOI: <https://doi.org/10.1080/01973533.2011.614166>
- Long, L. L. (2020). Toward an antiracist engineering classroom for 2020 and beyond: A starter kit. *Journal of Engineering Education*, 109(4), 636–639. DOI: <https://doi.org/10.1002/jee.20363>
- Long, L. L., & Mejia, J. A. (2016). Conversations about diversity: Institutional barriers for underrepresented engineering students. *Journal of Engineering Education*, 105(2), 211–218. DOI: <https://doi.org/10.1002/jee.20114>
- Martin, J. P., Simmons, D. R., & Yu, S. L. (2013). The role of social capital in the experiences of Hispanic women engineering majors. *Journal of Engineering Education*, 102(2), 227–243. DOI: <https://doi.org/10.1002/jee.20010>
- McGee, E. O. (2016). Devalued Black and Latino racial identities: A by-product of STEM college culture? *American Educational Research Journal*, 53(6), 1626–1662. DOI: <https://doi.org/10.3102/0002831216676572>
- McGee, E. O., & Martin, D. B. (2011). “You would not believe what I have to go through to prove my intellectual value!” Stereotype management among academically successful Black mathematics and engineering students. *American Educational Research Journal*, 48(6), 1347–1389. DOI: <https://doi.org/10.3102/0002831211423972>
- Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative Research: A Guide to Design and Implementation*, 4th ed. San Francisco, CA, USA: Jossey-Bass
- Miles, M. L., Brockman, A. J., & Naphan-Kingery, D. E. (2020). Invalidated identities: The disconfirming effects of racial microaggressions on Black doctoral students in STEM. *Journal of Research in Science Teaching*, 57(10), 1608–1631. DOI: <https://doi.org/10.1002/tea.21646>
- National Academies of Sciences Engineering and Medicine. (2018). *Graduate STEM Education for the 21st Century*. DOI: <https://doi.org/10.17226/25038>
- National Science Foundation, & National Center for Science and Engineering Statistics. (2019). Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019 | NSF – National Science Foundation. DOI: <https://doi.org/NSF19-304>
- Nieto, N. (2018). Technology and gendered spaces: Examining equity and access. 2018 CoNECD The Collaborative Network for Engineering and Computing Diversity Conference. Crystal City, VA. <https://peer.asee.org/29584>
- NSB (National Science Board). (2018). Science and Engineering Indicators 2018. NSB-2018-1. Alexandria, VA: National Science Foundation. Available at <https://www.nsf.gov/statistics/indicators/>.
- O’Meara, K. A., Griffin, K. A., Nyunt, G., & Louder, A. (2018). Disrupting ruling relations: The role of the PROMISE Program as a third space. *Journal of Diversity in Higher Education*, 12(3), 205–218. DOI: <https://doi.org/10.1037/dhe0000095>
- Ong, M., Wright, C., Espinosa, L. L., & Orfield, G. (2011). Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. *Harvard Educational Review*, 81(2), 172–209. DOI: <https://doi.org/10.17763/haer.81.2.t022245n7x4752v2>
- Pawley, A. L. (2017). Shifting the “default”: The case for making diversity the expected condition for engineering education and making whiteness and maleness visible. *Journal of Engineering Education*, 106(4), 531–533. DOI: <https://doi.org/10.1002/jee.20181>
- Pawley, A. L. (2019). Learning from small numbers: Studying ruling relations that gender and race the structure of U.S. engineering education. *Journal of Engineering Education*, 108(1), 13–31. DOI: <https://doi.org/10.1002/jee.20247>
- Perez, R. J., Robbins, C. K., Harris, L. W., & Montgomery, C. (2019). Exploring graduate students’ socialization to equity, diversity, and inclusion. *Journal of Diversity in Higher Education*, 13(2), 133–145. DOI: <https://doi.org/10.1037/dhe0000115>

- Perkins, H., Bahnsen, M., Tsugawa-Nieves, M., Kirn, A., & Cass, C.** (2018b). WIP: Influence of laboratory group makeup on recognition and identity development in the engineering graduate student population. 2018 *IEEE Frontiers in Education Conference*. DOI: <https://doi.org/10.1109/FIE.2018.8658669>
- Perkins, H., Bahnsen, M., Tsugawa-Nieves, M., Kirn, A., & Cass, C.** (2020). An intersectional approach to explore engineering graduate students' identities and academic relationships. *International Journal of Gender, Science, and Technology*, 11(3), 440–465. <http://genderandset.open.ac.uk/index.php/genderandset/article/view/679>
- Perkins, H. L., Bahnsen, M., Tsugawa-Nieves, M. A., Kirn, A., & Cass, C.** (2018a). Development and testing of an instrument to understand engineering doctoral students' identities and motivations. 2018 *ASEE Annual Conference and Exposition*. DOI: <https://doi.org/10.18260/1-2--30319>
- Pietri, E. S., Hennes, E. P., Dovidio, J. F., Brescoll, V. L., Bailey, A. H., Moss-Racusin, C. A., & Handelsman, J.** (2019). Addressing unintended consequences of gender diversity interventions on women's sense of belonging in STEM. *Sex Roles*, 80(9–10), 527–547. DOI: <https://doi.org/10.1007/s11199-018-0952-2>
- Ramirez, E.** (2014). “¿Qué estoy haciendo aquí? (What am I doing here?)”: Chicanos/Latinos(as) navigating challenges and inequalities during their first year of graduate school. *Equity and Excellence in Education*, 47(2), 167–186. DOI: <https://doi.org/10.1080/10665684.2014.900394>
- Ro, H. K., & Loya, K. I.** (2015). The effect of gender and race intersectionality on student learning outcomes in engineering. *Review of Higher Education*, 38(3). DOI: <https://doi.org/10.1353/rhe.2015.0014>
- Robnett, R. D.** (2016). Gender bias in STEM fields: Variation in prevalence and links to STEM self-concept. *Psychology of Women Quarterly*, 40(1), 65–79. DOI: <https://doi.org/10.1177/0361684315596162>
- Siegel, D. P.** (2019). Transgender experiences and transphobia in higher education. *Sociology Compass*, 13(10), 1–13. DOI: <https://doi.org/10.1111/soc4.12734>
- Sivesind, K. H.** (1999). Structured, qualitative comparison. *Quality and Quantity*, 33: 361–380. DOI: <https://doi.org/10.1023/A:1004691318311>
- Smith, D. E.** (1987). *The everyday world as problematic: A feminist sociology*. Boston: Northeastern University Press.
- Smith, D. E.** (1999). *Writing the social: Critique, theory, and investigations*. Toronto, Canada: University of Toronto Press. DOI: <https://doi.org/10.3138/9781442683747>
- Sowell, R., Allum, J., & Okahana, H.** (2015). *Doctoral Initiative on Minority Attrition and Completion*. Washington, DC.
- Sue, D. W., Bucceri, J., Lin, A. I., Nadal, K. L., & Torino, G. C.** (2007). Racial microaggressions and the Asian American experience. *Cultural Diversity and Ethnic Minority Psychology*, 13(1), 72–81. DOI: <https://doi.org/10.1037/1099-9809.13.1.72>
- Tesch, R.** (1990). *Qualitative research: Analysis types and software tools*. Bristol, PA: Falmer.
- Truong, K. A., Museus, S. D., & McGuire, K. M.** (2016). Vicarious racism: A qualitative analysis of experiences with secondhand racism in graduate education. *International Journal of Qualitative Studies in Education*, 29(2), 224–247. DOI: <https://doi.org/10.1080/09518398.2015.1023234>
- Trytten, D. A., Lowe, A. W., & Walden, S. E.** (2012). “Asians are good at math. What an awful stereotype”: The Model Minority Stereotype's impact on Asian American engineering students. *Journal of Engineering Education*, 101(3), 439–468. DOI: <https://doi.org/10.1002/j.2168-9830.2012.tb00057.x>
- Vargas-Ordaz, C. E., & Hynes, M. M.** (2020). Engineering design and social justice: A systematized literature review. *ASEE Annual Conference and Exposition, Conference Proceedings*, 2020-June. DOI: <https://doi.org/10.18260/1-2--34551>
- Verdín, D., Godwin, A. F., & Morazes, J. L.** (2015). Qualitative study of first-generation Latinas: understanding motivation for choosing and persisting in engineering. 2015 *ASEE Annual Conference & Exposition*. DOI: <https://doi.org/10.18260/p.24628>
- Walther, J., Sochacka, N. W., & Kellam, N. N.** (2013). Quality in interpretive engineering education research: Reflections on an example study. *Journal of Engineering Education*, 102(4). DOI: <https://doi.org/10.1002/jee.20029>
- Wang, M.-T., & Degol, J. L.** (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future Directions. *Educational Psychology Review*, 29(1), 119–140. DOI: <https://doi.org/10.1007/s10648-015-9355-x>
- Yosso, T. J.** (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education*, 8(1), 69–91. DOI: <https://doi.org/10.1080/1361332052000341006>

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