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ORIGINAL ARTICLE

Exploring the White and male culture: Investigating individual perspectives of equity and privilege in engineering education

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Abstract

Background: Engineering education in the United States has been accused of favoring White men at the exclusion of those traditionally underrepresented in engineering. However, contrary to the culturally responsive literature addressing approaches to "colorblindness," engineering faculty believe they should treat all students equally.

Purpose: This study explored conceptions of equity and privilege present within the culture of engineering education, particularly the White male population.

Method: This longitudinal qualitative study investigated the experiences of one longtime engineering professor, an insider to the culture of engineering confronted with conceptions of his own privilege. We analyzed interview, focus group, and field note data to evaluate shifts in our participant's perspective while he was enrolled in a doctoral program that challenged his views of race, privilege, and equity.

Results: Our participant was initially opposed to conceptions of his own privilege. Through repeated challenges to his beliefs about privilege coupled with reflections on his experiences and positioning in society, his beliefs shifted toward recognizing inequities based on class and race.

Conclusions: In a discipline with an overrepresentation of White men, there can be resistance to addressing topics of equity and privilege. However, it is possible for engineering educators, despite their race and gender, to change their beliefs related to the culture of engineering education and to address inequities within engineering departments and classrooms.

KEYWORDS

culture, equity, inclusivity, race/ethnicity, underrepresentation

1 | INTRODUCTION

Government-funded research has established that the combination of changing demographics and a predicted demand for more engineers in the United States signal a need for revolutionary changes in the preparation of engineers and the need for a more welcoming, diverse, and collaborative culture in engineering education (Jamieson & Lohmann, 2012; McGee & Bentley, 2017; National Science Foundation, 2014). Engineering faculty membership has historically descended from a dominant, homogenous, majority culture. Although experts in their field, these individuals have generally lacked both significant pedagogical training and a background in educational theory (Froyd & Lohmann, 2014), including an understanding of inclusive teaching practices. Understanding how to influence the culture of engineering education to successfully educate a diverse student body is an important and necessary ingredient for addressing national concerns with engineering and innovation. While

engineers are heralded as expert problem-solvers, it remains to be seen whether the approaches taken by the engineering education community will substantively influence the long-standing hegemonic practices responsible for an absence of diversity among engineering students and faculty in the United States.

Our research describes the journey of an experienced engineering educator, Roger (pseudonym), who after having established himself as a successful, tenured, university professor with nearly thirty years of experience, elected to join a cohort of colleagues and enroll in a science, technology, engineering, and math (STEM) education PhD program. Roger's doctoral program included specific and targeted experiences, which for him brought issues of equity, inclusivity, and diversity into focus. We write about his experiences, interpretations, and interactions with his doctoral cohort of engineering educators from the perspective of a longtime engineering educator accustomed to favorable job growth in his discipline (National Science Board, 2010).

Roger, a White male engineering faculty member, explained that prior to his STEM doctoral program, he had been insulated from underlying structural concerns that pointed to an engineering education crisis in the United States. He had not recognized the environment as unwelcoming, nor had he considered the forces responsible for perpetuating homogeneity within the discipline. Researchers have argued that engineering educators are "often unaware that cultures, like technological artifacts, are constructed and engineered by people" (Foor, Walden, & Trytten, 2007, p. 111). During his doctoral studies, Roger and the other members of his doctoral cohort were regularly challenged regarding notions of privilege, power, and equity. Roger slowly began to recognize that historically, opportunities in engineering had been constrained to a select few.

This research investigates the influence of several important experiences and reflective opportunities afforded Roger during his PhD program. We highlight one longtime, teaching-oriented faculty member known to be caring and compassionate toward students and focus on how his doctoral program experiences challenged his perspectives related to race and privilege. Despite the unique nature of this immersive experience and the receptiveness of the participant, our research illuminates the difficulty some engineering faculty may experience in adopting a progressive stance toward equity and privilege in the classroom.

We wish to add to the extant engineering education literature by focusing increased attention on engineering education culture as a potential obstacle to diversifying engineering. Our goal in this research is to encourage reflective and inclusive conversation related to diversity in engineering. We aim to achieve this goal by calling attention to the attributes of the field, by explicating the socialization that leads to the status of engineering disciplines, and by interrogating how the discipline has approached the notion of increasing diversity. The traditions of elitism, privilege, patriarchy and homogeneity among engineers and scientists have been well documented (Beddoes & Borrego, 2011; Blair, Miller, Ong, & Zastavker, 2017; Hutchison-Green, Follman, & Bodner, 2008; May & Chubin, 2003; Samuelson & Litzler, 2016). Maintaining such a limited view of education is at odds with expanding STEM membership beyond the dominant culture.

Our insider accounts and analysis of the influence of culture and race reported by engineering educators offer an unprecedented, finer-grained analysis of how individuals may recognize and respond to the role of race and culture in the engineering classroom. Our research offers insight to help educators make changes to support a more diverse, more inclusive, and more welcoming environment.

2 | LITERATURE REVIEW

The lack of diversity in engineering programs has received considerable attention. In 2004 alone, 13 Federal civilian agencies spent approximately $2.8 billion to increase the number of students in STEM fields and employees in STEM occupations (Ashby, 2006). Rigorous study regarding diversity and equity in engineering education literature has been wide-ranging, yet unsuccessful in remedying the dearth of diversity (Beddoes & Borrego, 2011; Blair et al., 2017; Chubin, May, & Babco, 2005; Foor et al., 2007; Margolis, Estrella, Goode, Holme, & Nao, 2010; May & Chubin, 2003; McGee & Bentley, 2017; Samuelson & Litzler, 2016; Seymour & Hewitt, 1997; Trenor, Yu, Waight, Zerda, & Sha, 2008). Educational research has identified a lack of a common understanding of the terms equity and equality (Espinoza, 2007; Samoff, 1996). For this research, we have adopted the position described by Samoff (1996) that is still relevant today. Equity seeks justice and fairness and "may require providing special encouragement and support for those who were disadvantaged in the past" (Samoff, 1996, p. 266). Equality involves treating everyone in the same fashion, which may result in the inequitable treatment of some members of society.

Despite an increase in engineering education research in recent decades, researchers have argued that mainstream engineering faculty members are largely unaware of the extant research in this area (Borrego, Froyd, & Hall, 2010; Jamieson & Lohmann, 2012), while fewer still are aware of equity-focused research in engineering education (Riley, Slaton, & Pawley, 2014). Researchers have claimed that publication practices have purposefully limited readership of equity focused research:

> Literature in engineering, engineering education, and engineering education research regularly relegates concerns of marginalized groups to specialized publications, or to a chapter or section where those who are concerned may read about it, but those with certain kinds of privilege need not encounter it. (Riley et al., 2014, p. 336)

Even when opportunities for faculty to learn about research-supported educational strategies arise through workshops, webinars, and presentations, various forms of resistance remain intact. These include lack of resources, faculty skepticism toward alternative teaching strategies, faculty trepidation of negative teaching evaluations (Borrego et al., 2010; Felder, Brent, & Prince, 2011), and engineering faculty mistrust in educational experts from outside the engineering disciplines (Felder et al., 2011).

Although studies seem to demonstrate efforts to an increase in the choice of a STEM major by underrepresented populations, barriers to retention and degree completion in STEM remain (Moakler & Kim, 2014). Engineering education researchers have argued that micro- and macrolevel institutional barriers continue to drive underrepresented populations from engineering and other STEM disciplines (Long & Mejia, 2016). Researchers have demonstrated that many explanations and proposed remedies situate the lack of representation squarely on the shoulders of underrepresented students, often through a deficit orientation (Martin et al., 2018; Samuelson & Litzler, 2016). The failure of remediation-focused approaches has already been well documented in K-16 STEM education efforts (Bettinger & Long, 2009; Martorell & McFarlin, 2011; Yerrick, Schiller, & Reisfeld, 2011). Categorizing low recruitment and retention as a lack of student preparation constrains the solution space to only those approaches that "fix" students without considering that the culture of engineering education may be at least partially responsible.

Despite extensive research that has demonstrated the ineffectiveness of lecturing as a primary teaching strategy (Felder, 2012; Prince & Felder, 2006), that traditional paradigm has "dominated engineering education since its inception" (Felder, 2012, p. 9). Evidence-based research suggests that revising engineering educational practices can positively influence the learning, success, and retention of underrepresented students. In their American Society for Engineering Education (ASEE) report, Jamieson and Lohmann (2012) argued that although engineering educators have shown interest in making programs more engaging for students, "there is much less emphasis or attention to making them more welcoming, especially to groups traditionally underrepresented in engineering" (p. 7). Some education researchers have even argued for culturally inclusive teaching approaches that explicitly address culture, race, and ethnicity (Gay, 2000; Ladson-Billings, 2000; Rodriguez & Kitchen, 2005). Considering some areas of engineering are the most culturally homogenous of all STEM disciplines (e.g., computer and electrical engineering), we believe engineering is a prime candidate for wider adoption of inclusive pedagogical strategies.

The perspective that students need only to work harder is often held by professors who staunchly resist alternative educational frameworks (Trent, Artiles, & Englert, 1998). The deficit and marginalizing assumption, which gets passed on within the culture, promotes the notion that underrepresented students are not yet working as hard as their majority peers. Recent studies have characterized notions of working hard, competing, and enduring as attributes engineers proudly profess, all of which end up being conveyed as expectations for engineering students (Christman, 2017; Long & Mejia, 2016; Marra, Rodgers, Shen, & Bogue, 2012; McGee & Bentley, 2017). The climate created as a result of these expectations may be responsible for students electing to leave engineering disciplines (McGee, 2016; Seymour & Hewitt, 1997).

This mind-set absolves faculty from considering that their teaching practices may be contributing to the lack of student success. In a multiyear project investigating the alignment of engineering education practices with recent calls for change in engineering education, researchers argued that

> undergraduate engineering education in the United States is holding on to an approach to problem solving and knowledge acquisition that is consistent with practice that the profession has left behind…and allow[s] little opportunity for students to have the kind of deep learning experiences that mirror professional practice and problem solving. (Sheppard, Macatangay, Colby, & Sullivan, 2008, p. xxi)

Alternative learning environments that promote these deep learning experiences have been shown to enhance academic performance for a diverse student audience (Eddy & Hogan, 2014; Freeman et al., 2007).

Marginalization of Black, Latinx, and Native American students can be attributed to several factors at different stages from preparation to recruitment to retention. When compared to other disciplines, students of color are more likely to experience being underprepared for or deterred from STEM disciplines in K-12 spaces (Mutegi, 2013). Students from underrepresented populations often find the environments in engineering programs, including interactions with faculty and peers, unwelcoming (McGee, 2016; Robinson, McGee, Bentley, Houston, & Botchway, 2016). More generally, the concept of structural racism informs us that educational institutions can exist as racialized systems that develop and perpetuate the status quo through

policies, institutional practices, cultural representation (or lack of representation), and sociocultural norms in academic and professional contexts (Bonilla-Silva, 1997, 2017). Structural racism as an analytical perspective draws close attention to the historical, cultural, and social aspects of our racialized society. It helps to explain the interconnection of various areas (e.g., education, legal, and health disciplines) and how people of color are disproportionately marginalized and oppressed. Structural racism explains how people construct their understandings of race and racial stratification, and creates an experiential dichotomy between people of color and White people (Harper, 2012).

To understand and subsequently remedy this problem, we must address the systemic marginalization present within our educational systems. Ladson-Billings (2000) has argued that only when we openly critique racialized systems and fully explain the historical origins of this division, can we make progress to extricate barriers and open new opportunities. McIntosh (1989) described her recognition of White privilege as emerging when she began to interrogate conceptions of male privilege. She argued that Whites are carefully educated to be unaware of White privilege, which ultimately becomes unconscious oppressiveness. Similarly, Howard (2006) explained that to carry out the day-to-day activities of their lives, members of the dominant group in any society are not necessarily required to know anything about those outside the dominant culture. We have found such a critical race critique throughout STEM education research (McGee, 2016; Mutegi, 2013; Ridgeway & McGee, 2018; Ridgeway & Yerrick, 2016; Rosa & Mensah, 2016) particularly related to science and mathematics education reform. Critical race awareness and recognition of racial disparities can and should permeate conversations about diversity in engineering, but how do we initiate these conversations? Only after directly engaging with college students traditionally underrepresented in STEM did engineering faculty begin to fully appreciate the disparity of educational opportunity between urban and suburban landscapes (Eastman, Christman, Zion, & Yerrick, 2017).

Many authors (Long & Mejia, 2016; Samuelson & Litzler, 2016; Yosso, 2005) have argued that cultural norms of behavior, rewards, and disciplinary structures implicit in engineering, such as the values of competition and individualism, can be institutionalized and, thus, tend to limit access to resources for specific underrepresented STEM students. Others have described an intricate racialized system that actively perpetuates discriminatory and biased practices against people of color (Joseph, Hailu, & Boston, 2017; McGee, 2016), while simultaneously reproducing and fostering privilege of White people and Whiteness. White men and women can exhibit behaviors that are racist and hostile toward people of color consciously, unconsciously, or as King (1991) added, dysconsciously (having a distorted understanding of systems of power and privilege and their role in it). Scholars of Whiteness have drawn attention to the irony that members of the White ethnic population are often the least aware of the contextual and social impact of their culture (Delgado & Stefancic, 1997; Gillborn, 2005; Leonardo, 2009). As a result, the simple fact that predominantly White men currently occupy academic positions in engineering schools can be a challenge for creating inclusive pathways in postsecondary engineering environments. Building awareness (within the dominant culture) of the broad social implications of White culture may be a first step in creating a more welcoming engineering academy.

3 | THEORETICAL FRAMEWORK

Intercultural examinations of race and privilege in educational contexts (Delpit, 1988; Emdin, 2017; Milner, 2010; Nelson, 2016) have influenced our work. As we endeavored to categorize, qualify, and to some extent quantify the shift in Roger's espoused beliefs during his time in the doctoral program, the widely cited work of Howard (2006) came to the forefront. In our research, we have seen that White engineers may find themselves at different stages of understanding culture and race, and often navigate their own pathways to equitable practices. The selected path may or may not lead to equitable actions including culturally responsive teaching. As Banks, Murry, Brown, and Hammond (2014) described

> it is essential for researchers to investigate mechanisms through which White individuals come to develop a positive White identity, where an individual acknowledges the existence of racism and White privilege in society and explores images of Whiteness that are not oppressive. (p. 203)

To develop a positive White identity, one must abandon individual racism and recognize and actively oppose institutional and cultural racism (Helms, 1990). Much of the research on White racial identity focuses on the awareness of White privilege, but it should additionally explore the development of a positive White identity (Banks et al., 2014; Helms, 1990). Howard (2006) specifically addressed his own protracted understanding of White male culture and how that culture influenced his approach to race and marginalization. We have summarized some ways Howard identified White trajectories toward advocacy through behaviors, beliefs, and actions that inform and situate orientations of White educators in Table 1. By interrogating and

TABLE 1 Howard's (2006) framework describing White identity orientations

	Fundamentalist	Integrationist	Transformationist
Thinking	Deny, legitimize, or rationalize White construction of dominance	Some self-interrogation and dissonance and acknowledgement of diverse perspectives	Actively seeking divergent truths about cultural dominance and superiority
Feeling	My perspective is right. Hostility toward challenging beliefs	Beginning awareness, someone else's problem, self-esteem linked to helping others	Enlightened aversion to oppression, honesty, self-esteem linked to change
Acting	Monocultural, treating all people the same. Autocratic, directive, perpetuates White dominance	Accommodates diversity in "special programs," patronizing, seeks only commonalities	Advocacy, actively dismantles White dominance, social action, challenging, healing, rewarding

Note: For a more complete description of Howard's characterization, see Howard (2006, p. 104).

reflecting on their own racial identities and developing a positive White identity, we believe White engineering faculty can be more effective in helping to foster an inclusive community of educators and professionals.

The White Identity framework (Howard, 2006) enabled us to develop an understanding of a trajectory of change related to perspectives of race and culture. In this study, we explore conceptions of equity and privilege through the lens of one White male engineering professor. Howard's framework allowed us to reflect on our participant's trajectory and recognize environmental requirements for influencing change within engineering education. Our intent is to interrogate the framing of the lack of diversity among engineering students as an issue of White privilege. To this end, we pose the following research questions:

- How does an engineering educator's racial identity inform his beliefs and actions toward equity in engineering?
- In what ways did educational tasks oriented toward explicating culture and privilege influence one experienced engineering educator's understanding of equity and diversity?

4 | METHOD

Our instrumental case study (Creswell, 1998; Merriam, 2009) used ethnographic tools to examine the experiences, reflections, and racial identity of one White, male, college engineering educator. Our goal in this approach, which included an extended observation period and placing a primacy on the interview process, was to explore how our participant's experiences influenced his perspectives on race and privilege and to provide general insight into the culture of engineering education. Our participant, Roger, was a member of a cohort of 10 experienced engineering faculty selected and funded by their Dean to pursue doctoral degrees in STEM education with the goals of improving teaching, increasing the capacity of his college to conduct educational research, and enhancing the pedigrees of individual faculty members. The Dean's long-term goals included establishing a STEM Education Center to secure future STEM education research funding.

4.1 | Participant selection

Middleton, Anderson, and Banning (2009) used narrative analysis to demonstrate that, for those in the dominant culture, the journey to recognizing and understanding privilege is unique to each individual. Using transformative learning theory, the authors explained that some individuals experienced dramatic shifts in perspectives related to privilege, while others developed understanding more gradually. Independent of the acuteness of the shift, all participants embarked on a "path of critical reflection or introspection and self-disclosure as the road to" understanding their privilege (Middleton et al., 2009, p. 301). Our research is part of a larger study, published as a doctoral dissertation (Eastman, 2017), that included an in-depth analysis of the experiences of four PhD candidates (two White men and two White women) related to the culture of engineering education. Roger was one of three participants from that research deemed to have experienced a significant shift in perspectives of equity and privilege. Another participant in that study, a White man, demonstrated only a minor shift with respect to equity and privilege.

We have elected to focus on Roger for a variety of reasons. He had established a long history of success as an engineering teaching professor, a White male in a culture dominated by White men. The opportunity to analyze Roger's shifts in perspectives as a result of his experiences in the PhD program is unique, and he was open to sharing his reflections and how the program challenged his beliefs. Roger had established trust with the research team as he and the first author had been colleagues in similar disciplines for many years. Roger was willing to reflect on his racial identity as a White male, his personal feelings and experiences with challenges to his perspectives on race and privilege, and the discomfort he felt when challenged to

implement inquiry-based teaching strategies. This unique scenario enabled us to deeply explore the complexities, unevenness, and conflict apparent when interrogating White identity and provided insight into the circumstances that fostered change.

Engineers practice in professional learning discourse communities with established goals, values, and beliefs. Like other discourse communities, their shared norms of thinking, speaking, and acting drive and shape customs and practices that are mutually understood and result in specific outcomes (Jamieson & Lohmann, 2009; Johri & Olds, 2014; Liu, Carr, & Stroebel, 2009). As researchers, we would not necessarily expect these shared practices to overlap with other discourse communities, such as those of an educational scholarly community. We therefore anticipated that the establishment of a separate doctoral learning community, where engineers could consider and juxtapose other frameworks with engineering education, would represent a rare opportunity for research. In this unique context, engineers like Roger could study literature and research methods outside of their technical fields, recognize the isolation of disciplinary studies, and make fruitful transitions away from the long-standing practices identified as contributing to an unwelcoming environment for students traditionally underrepresented in engineering (Blacks, Latinxs, Native Americans, and women).

Our research was guided by recommendations from engineering education researchers who have argued for more diverse representation of methodological frameworks (Borrego, Douglas, & Amelink, 2009; Case & Light, 2011; Foor et al., 2007; Fortenberry, 2014). We drew from the qualitative methods of both ethnographic and phenomenological approaches (Creswell, 1998; Glesne, 2011; Moustakas, 1994; Smagorinsky, 2008). Adopting these perspectives enabled us to narrate Roger's unique story reliably and with a deep understanding of the situations that influenced shifts in his perspective. It is not our intention that the findings from this research are generalizable for all engineering educators. Rather, in the paradigm of qualitative research, the case of Roger illuminates a longtime engineering educator's perspective into the culture of engineering and provides insight into mechanisms that may influence change. It is our hope that readers recognize and reflect on parallels between Roger's struggle to understand the social context of the engineering education environment and their own experiences and behaviors as educators.

In the qualitative paradigm, the researcher is an instrument in the processes of data collection and analysis, the critical analysis tool responsible for influencing the co-construction of meaning during the conversational interaction between interviewer and interviewee (Howe & Eisenhart, 1990; Mishler, 1991). Because this co-construction process is embedded in the data collection and analysis, we believe that the first author's status as an engineering insider lends a greater credibility to the argument we present as he was able to recognize, interpret, and capture the nuanced nature of an insider's account of the culture of engineering education.

As a research team comprised of one engineering education insider and two educators from outside the engineering disciplines, we were able to press the line of insider versus outsider by critically exploring assumptions of engineering educators and by checking our claims and assertions against a broad spectrum of artifacts and events over several years and contexts. Entering into our work with a critical lens, we sought to account for the beliefs about race, class, and colorblind ideologies, which have minimized the different treatment of students of color, ignoring the stark contrast when compared to how their White peers describe the same context (Harper, 2012; McGee, 2016; Walls, 2015).

4.2 | Context of the study: An insider perspective

The first author is a White man, who, through more than two decades as an engineering education faculty member and the completion of a doctoral program focused on STEM education research, has developed an intimate understanding of the culture of engineering education. Like Roger, during their shared experience in the doctoral cohort, the first author struggled with conceptions of privilege and the understanding of diversity, and considers these to remain as personal, ongoing struggles of continued learning. Our research team consists of two White men and one Black woman who have experienced success in engineering education, chemistry education, and geology education. As collaborative authors, we hope to interrogate our own biases as we study issues of equity and diversity in engineering. By offering our critical view of race, gender, and culture in this study, we wish to offer a needed transparency for others regarding the culture of engineering and help readers interpret their place in it. From our own experiences as students and faculty, and through the knowledge we have gained researching others, we have come to believe that combining structural racism and White racial identity development can encourage engineering faculty, most of whom are White males, to be more reflective and inclusive of people of color. Our position is not that engineering insiders have intentionally engaged in a wide-ranging conspiracy to prevent the success of individuals from outside the dominant culture. Rather, we believe more subtle undertones permeate the culture.

4.3 | Data collection and analysis

We implemented a multifaceted approach to collect and analyze data from a variety of sources including (a) handwritten field notes from observations of doctoral courses Roger attended, (b) reflective journal entries written by Roger in his doctoral

TABLE 2 Data collection timeframe

Data source	Timeframe collected
Handwritten field notes	Four years of doctoral program
Reflective journal entries	First 2 years of doctoral program
Two formal interviews	Second year of doctoral program
Three informal interviews	Two in the second year and one in the final year of doctoral program
Learning artifacts	First 3 years of doctoral program
Teaching artifacts Roger created	Final year of doctoral program
Focus group	Final year of doctoral program

courses, (c) interviews the first author conducted with Roger, (d) learning artifacts from doctoral courses, (e) teaching artifacts Roger created, with the goal of applying what he learned in the doctoral program to the courses he taught, and (f) a focus group with several members of Roger's doctoral classmates. In our role as researchers, we were active listeners and learners, developing understanding from and with our participant, as we reconstructed Roger's lived experiences from his own perspective (Glesne, 2011). We gathered data for this project, as described in Table 2, over a 4-year period when Roger was enrolled in courses for the doctoral program at Northern University (pseudonym). Together, the data sources permitted us to establish trustworthiness as we triangulated the veracity of each research assertion.

For the two formal interviews, we adopted a semi-structured approach following the guidelines of Mishler (1991) and Seidman (2013). Interview protocols channeled the direction and content of the discussion based on overarching themes, while the semi-structured approach allowed the interviewer to deeply explore Roger's lived experiences. The first author conducted both formal interviews and transcribed each verbatim. After each interview, the team of authors examined the transcription and "pull[ed] out the concepts and themes that describe[ed] the world of the interviewee, and decide[d] which areas should be examined in more detail" (Rubin & Rubin, 2011, p. 226). The formal interviews each lasted approximately 90 min and were separated by approximately two weeks. This spacing enabled the research team time to review and analyze the first interview and determine a strategy for the second. We also conducted three informal interviews. Two of these discussions addressed specific aspects of the experiences Roger described in the formal interviews and the third followed a classroom observation of Roger's teaching. This approach enabled us to reconstruct a trustworthy account of how Roger's perspectives about the culture of engineering education were influenced during his doctoral program.

We sought to confirm or refute proposed themes about Roger's beliefs, thinking, and acting through the triangulation of various data sets and longitudinal member checks (Erlandson, 1993; Lincoln & Guba, 1985). Only themes that were corroborated by at least three different data sources were retained and forwarded to the final analysis. This step was essential for deciding on the final narrative as we repeatedly returned to Roger to restate and reevaluate our interpretation regarding his espoused perspectives to construct a trustworthy account. For example, during an interview, Roger explained he was familiar with constructivism, but that it was not something he had "synthesized…to a cohesive thought process" (Interview, second year). Field note evidence, collected during classroom observations of Roger's teaching, confirmed his discomfort with constructivist teaching strategies. A critical component of our analysis was our ability to share our interpretations with Roger, and Roger's willingness to read and react to them. We continually invited Roger to confirm, refute, and whenever necessary, correct our account.

We selected a multitiered approach to coding our data. The initial thematic analysis of the preliminary interview (Rubin & Rubin, 2011) provided a broad understanding of Roger's experiences. As we reviewed and evaluated data, we developed codes to refine our data categorizations and to facilitate understanding of connections within and across categories. As we continued to gather data, we realized, in some instances, we had defined our initial codes too broadly. To organize data into more precise and meaningful categories, we refined some codes while discarding others. For example, we had originally selected the term *privilege* to represent any instance of our participant describing privilege within field notes, interview transcriptions, or journal entries. We eventually recognized that Roger referenced privilege in a variety of contexts. Because of this, we developed several subcategories for privilege, which included more descriptive terms of denying, recognizing, and exposing one's own. A list of codes including those retained, added, or discarded is provided in Table 3.

As we began to understand Roger's changing perspectives resulting from his participation in the PhD program, we viewed Roger's progression through the lenses of White racial identity and the understanding of White privilege (Banks et al., 2014). We sought a framework that accurately and consistently explained our evidence as we revisited our observations of Roger's complex and sometimes unpredictable transitions, progression, and regression. We focused on the framework of Howard

TABLE 3 Examples of thematic codes developed inductively

	Initial	Retained/modified/added	Discarded
Thematic codes	Privilege	Privilege—denying	New learning
	Constructivist	Privilege—recognizing	Resistance
	Positivist	Privilege—exposing one's own	Challenges
	STEM elitism	Constructivist	Traditional science
	New learning	Positivist	Impact on personal life
	Resistance	STEM elitism	Impact on research
	Challenges	Equity versus equality	Student preconceptions
	Equity versus equality	Race and ethnicity	
	Race and ethnicity	Teaching—reflections	
	Teaching	Teaching—as facts	
	Traditional science	Teaching—teacher centered	
	Impact on personal life	Teaching—student centered	
	Impact on research	Research—attitude toward	
	Student preconceptions	White identity	
		Culture	

Abbreviation: STEM, science, technology, engineering, and math.

(2006) and independently analyzed our data against this framework with an interrater reliability of greater than 80% using the following strategies.

We applied the White Identity framework from Table 1 to each of Roger's espoused understandings of privilege. We categorized each individual data entry by modality of Howard's framework. We then assigned a granular attribution of Thinking, Feeling, or Acting to each piece of data. Finally, we evaluated each item to determine the minor category of modality present. For example, if the datum represented Roger's *Thinking*, we further evaluated it to determine if the modality represented a *Construction of Truth*, a *Construction of Whiteness*, or a *Construction of Dominance*. During our analysis, we recognized that some of Roger's quotes fit within multiple perspectives. For example, certain quotes could represent both *Thinking* and *Feeling*. In those instances, we categorized the data in both categories. Finally, we categorized each datum as Fundamentalist, Integrationist, or Transformationist. This further refinement of the coding process enabled us to identify Roger's orientation early in the doctoral program and to re-evaluate his perspectives near the conclusion of the program. This extended analysis and examination of agreement across author's separate interpretations refined the final narrative we present in our findings.

5 | FINDINGS

We report our findings by reconstructing Roger's narrative and demonstrating his perspectives on diversity and privilege, and the influences that shifted those perspectives. It is important to note that Roger's doctoral program was infused with recurring messages related to STEM education's long history of advantaging White men while underserving and excluding those traditionally underrepresented in STEM.

We will demonstrate that Roger struggled, and has continued to struggle, with understanding conceptions of his own privilege. The transition in Roger's understanding has been neither smooth nor consistent. It has ebbed and flowed like the tides, gathering steam, but then retreating only to return later. The cadence of this transition has been rhythmic perhaps but generally changing and sometimes unpredictable.

Finally, we recognize that entering a doctoral program late in one's career as an engineering faculty member and working closely with a doctoral program faculty member committed to equity and social justice research created a unique environment for meaningful change that would be difficult to replicate. We recognize enrolling in a doctoral program is an impractical endeavor for most engineering educators. However, we believe other engineering faculty could benefit from experiences similar to those that influenced Roger. This research offers insight to help transition the culture of engineering education to become more welcoming and more beneficial for a diverse body of learners.

Based on our study, Roger's perspectives shifted because of experiences he encountered during his doctoral program. While it would be outside of the bounds of this study to claim a permanent shift in perspectives of equity and privilege for this longtime engineering faculty member, we are encouraged by the prospect that a shift in perspective is possible.

5.1 | An understanding of Roger's perspectives early in the doctoral program

Prior to entering the doctoral program in STEM Education, Roger had been a teaching-focused faculty member at Western Engineering College (pseudonym) for nearly thirty years. When we asked Roger about his motivation for pursuing a PhD so late in his career, he explained

> I've always wanted to get a PhD…when I started teaching at 23, it wasn't required [at Western Engineering College]…but the thing that's changed over the years is I always thought I'd get a PhD in a technical area. But the more I've progressed through my career, the more I've realized that I'd rather have a PhD in a nontechnical area and more focused on teaching and less on technology…focusing on the pedagogy of teaching and learning. (Interview, second year)

Roger explained, when he was first hired at Western Engineering College, teaching was the primary focus. A terminal degree was not required, and faculty was not expected to engage in funded research. Although he was beyond the midpoint of his career, he felt the opportunity to pursue a doctoral degree with a cohort of peers aligned well with his capabilities and enabled him to pursue the PhD he had "always wanted." Perhaps even more important, Roger shared his concerns about the changing culture at his university: "Without a PhD you're rapidly becoming irrelevant here." He believed acquiring an education-focused PhD would help him remain a valuable contributor to the mission of his university.

Roger's work ethic is an important component of his identity and influenced his approach to teaching. During a study session with fellow classmates in the doctoral program, Roger explained, "I was the youngest of nine kids and my father worked two jobs. I later learned my mother often went to bed hungry because she put us kids first. We didn't have any *extras*" (Field notes, second semester). Roger's upbringing had instilled in Roger a strong work ethic and sense of duty. He was the only one in his large family to attend college, and he felt he had earned everything he had accomplished. The characteristics of hard work and individualism are so woven into the fabric of Roger's identity that he has traditionally attributed poor student performance to students' lack of effort. During an interview in the second semester of Roger's PhD program, the first author asked Roger how, if at all, the doctoral experience had influenced his perspectives on teaching. In Roger's response, he offered:

> As engineers, we're problem solvers. Ya know, students aren't succeeding. What do we need to do? We need to make 'em work harder. That's how we did it, that's how they should do it. This is how we solve the problem. We never investigated what the problems were. We assumed we knew. (Interview, second year)

In this statement, Roger used the pronoun "we" to indicate that prior to entering the doctoral program, he and others at his home institution had believed that making students "work harder" would promote success. This self-reliant, hard-working characterization matched much of what Roger described of his own background. Roger entered the doctoral program holding firmly to the belief that his success in academia, as both a student and accomplished faculty member, was due to his own hard work and unrelated to his race or gender.

The statement above provides insight into Roger's early perspectives and how those perspectives had begun to shift during the doctoral program. Roger framed his prior educational philosophy in the pejorative. By the second semester of immersion in the doctoral program, he had begun to recognize approaches to student success beyond pushing them to work harder. We noted this shift and applied Howard's (2006) White Identity framework to this quotation from two perspectives. First, we applied Howard's framework to the perspective Roger described when entering the doctoral program—working harder is all that is necessary for student success—as Fundamentalist. This statement portrayed a White western-centric viewpoint that was both fixed and literal, and that there was only one perspective—his own.

Second, because we understood Roger's explanation to be a reflection of his perspectives at the beginning of the doctoral program, we also interpreted that Roger demonstrated some growth, or shift, along the "journey of White identity development" (Howard, 2006, p. 87). As such, we interpreted Roger's reflection as a beginning awareness of his emotional response to differences as he was confronted with conceptions of his own privilege. Roger demonstrated self-interrogation by recognizing that his initial conception of a "hard work" solution was flawed. Therefore, we categorized Roger's progressing development as moving toward Integrationist.

Mastering the content, designing solutions, and finding the correct answer are the actions carried out by academically successful engineering students. These skills map nicely onto the perceived expert actions of achieving, competing, problem solving, surviving, and working hard in engineering and have long been understood as central to the success and identities of engineers and engineering students. Roger recognized the implicit stance of engineering educators toward their students to "pick

themselves up by their bootstraps" in a culture that rewards self-reliance and survival. However, Roger was unaware of the strong negative impact this message has had upon underrepresented students, placing the responsibility of enculturation on the student. Although these attributes are regarded positively among engineers, these perceptions of the discipline and its membership can serve as barriers for engineering educators who attempt to understand alternative constructions of teaching and learning.

Early in the doctoral program, Roger understood his success as an engineering student to result from his personal work ethic. His contention that hard work is the primary component required for success in engineering precluded any conceptions that the culture of engineering education may favor some individuals. Although Roger had graduated from college several decades earlier, his argument that hard work is paramount to success continues to echo through engineering hallways as demonstrated by the recent work of Christman (2017) in her characterization of successful, male engineering students.

5.2 | Roger and colleagues were confronted with conceptions of their own privilege

The persistent expectation for engineering faculty to reflect on their own privilege was embedded throughout the coursework Roger completed. Many faculty members in Roger's doctoral program challenged the overtly elitist norms of speaking, thinking, and acting in engineering and recast pedagogical and research conversations to challenge the thinking of Roger and his classmates. However, none did so with more tenacity than Dr. Smith. A White, middle-class education researcher, Dr. Smith relentlessly interrogated cultural assumptions and introduced conversations even about his own bias and his own institution's lack of attention to STEM inequity. Dr. Smith wished to help this group of engineering faculty members recognize the systemic structural barriers in STEM education that have been placed in front of those outside the dominant culture. As an advisor and mentor to several members of Roger's cohort, Dr. Smith provided safe spaces online and in person for this close-knit learning community to challenge one another as they digested the work of contemporary equity researchers Alberto Rodriguez (Rodriguez & Kitchen, 2005; Rodriguez, Zozakiewicz, & Yerrick, 2005), Angela Calabrese Barton (Calabrese Barton, 2003), Gloria Ladson-Billings (Ladson-Billings, 2000; Ladson-Billings & Tate, 1995), Geneva Gay (Gay, 2000), Gary Howard (Howard, 2006), Lisa Delpit (Delpit, 1988, 2006), and many others outside their disciplinary literature. He also arranged for live interactions with authors about their work and encouraged his students to explore and apply modern STEM equity research.

At several points in his doctoral program, Roger expressed frustration that Dr. Smith had repeatedly confronted the doctoral students about their privilege. He shared this frustration with us during interviews and the focus group, and we witnessed his frustration during interactions with his doctoral classmates. During a group discussion in the first semester of the doctoral program, Roger's reaction to Dr. Smith's challenges about privilege was immediate, defensive, and direct:

> None of *us* [cohort members] grew up with a silver spoon in our mouth. We all came from very little, and earned everything we have. My parents worked hard to support our family, and I have worked hard to support mine. I'm here because of my own hard work. (Field notes, first semester)

In this statement, Roger referred to the members of his cohort, all White middle class and predominantly men, as not having received the advantages of privilege. Roger attributed his accomplishments to his work ethic and deflected any assertions of his own privilege.

During discussions with Roger early in the doctoral program, he consistently rejected any suggestions that he was privileged (Field notes, first and second semesters). Early in his doctoral program, a classmate challenged Roger's beliefs about privilege by suggesting that K-12 students in the urban district near Western Engineering College did not receive the same advantages as students from many local suburban school districts:

> Roger: I don't see this as an issue of White privilege. This is a societal problem that we can't fix. The family unit in the urban districts has disintegrated.
> Colleague: But, don't you think the suburban school districts provide much greater opportunities than the [local urban district]? Some of the urban students just don't have a chance.
> Roger: Your son is a strong student. If he attended the [local] city school district, he would do just fine. It doesn't have anything to do with White privilege. (Field notes, first semester)

Roger's use of the term White privilege illustrates a misunderstanding of how Whiteness operationalizes to reinforce structures of inequality. In fact, he exposed his understanding that race and gender have little impact on educational outcomes of White people. He argued that because his White colleague's suburban son was a "strong student," he would be successful in the urban school district. Roger's deficit-minded thinking implied that students who are performing poorly in the urban districts

are doing so because they are not strong students. Discussions such as the one above occurred regularly between members of the doctoral cohort as they reflected on topics of race, equity, and privilege that challenged their thinking.

Using Howard's (2006) identity orientation framework, we categorized Roger's perspectives expressed in the statements above as Fundamentalist. Our interpretation is that Roger portrayed a literal construction of truth that was western-centric and unidimensional. He rationalized his perspective and his accomplishments as being a result of work ethic—his own, and his family's. Additionally, Roger's assumption that a "strong student" from the suburbs would be successful in the urban school district exposed a perspective of White superiority and dominance which alludes to the unequal educational resources available to the son (also a White male) compared to his urban peers. We can even problematize the notion of being in an urban school district as a White male. As such, he would still receive the benefits of being White and having the best the school district has to offer, while students of color would still experience unequal access to academic resources (Parsons, 2005; Yerrick & Hoving, 2003).

Beginning in the first semester, the doctoral program challenged Roger and his colleagues with readings and discussions related to equity in the classroom. Dr. Smith implored them to consider that many educational opportunities have traditionally been reserved for the middle class, especially for White men. Throughout much of the first year, Roger's resistance to the professor's prodding about privilege and White-male-centric pedagogical practices and opportunities remained stalwart. Roger continued to assert that he had *earned* everything he had acquired, from his middle-class status to his comfortable suburban home, and that opportunities afforded him were no different from those available to everyone else in the country (Field notes, first and second semesters).

During an interview, Roger shared his reactions to Dr. Smith's challenges regarding privilege:

> When you're told you're privileged, it comes across as a slight if you will, like you've got something you haven't earned. We've got to our place in our life because we've worked very hard. And to say you're privileged almost implies you were given these opportunities. So, it puts you back in your heels and makes you defensive, and you tend not to listen to that. No one wants to hear that. (Interview, second year)

In the reflection above, Roger recognized, despite the direct challenges from Dr. Smith, he had continued to resist notions of his own privilege. Although Roger had initially felt wrongly accused, as he progressed through the doctoral program he reflected on his own privilege and the opportunities he had received in his lifetime. Roger recognized that his reaction of becoming "defensive" resulted from the implication that things were "given" to him. Roger's sense of accomplishment was grounded in his own work ethic, and to adopt the label of privilege would undermine that sense of accomplishment. When we applied Howard's (2006) framework to Roger's statement above, we recognized feelings that aligned with fear and avoidance. We interpreted his statements to reflect initially feeling threatened by the accusations of the Northern University faculty. We interpret his feelings related to difference and racism as initially Fundamentalist.

Ultimately, developing an understanding of privilege would require more than exposure to education literature and prodding from his professor. Soon, Roger would participate in research project focused on diversity, a pivotal component in his preparation, which would influence the progression of his understanding of privilege.

5.3 | Shifts in Roger's perspectives during the doctoral program

Prior to participation in the doctoral program, Roger admittedly had little understanding of cultural differences in his classroom and did not have an appreciation for how those differences influence student learning. He believed it appropriate to treat all students equally. Roger had practiced what researchers have criticized as a "discourse of invisibility" (Rodriguez, 1997, p. 19). Although Roger's treatment of students was well intended, his lack of understanding of the difference between equity and equality, and his desire to maintain a "colorblind" (Walls, 2015, p. 5) perspective advantaged the students who looked and acted like Roger (White men). Prior to the doctoral program, Roger had not been exposed to culturally responsive teaching (Gay, 2000) nor sociocultural research related to student learning (Calabrese Barton, 2003; Rodriguez & Kitchen, 2005; Suriel & Atwater, 2012). As an engineering faculty member, Roger had been educated and socialized within a system that has historically advantaged White men over women and people of color. Like many other engineering faculty, his career path had insulated him from educational theory and cultural differences in learning as these topics have been historically absent in the preparation of engineering educators (Froyd & Lohmann, 2014).

5.3.1 | Listening to the voices of marginalized students

During his doctoral program, Roger had several learning experiences designed to engage him directly and vicariously with students with educational and life experiences unlike his own. One assignment engaged Roger and a team of doctoral

classmates in a multi-semester research project focused on local children of color living in poverty and a scholarship program meant to enhance student diversity among undergraduate STEM majors. Participating in this project provided Roger with his first in-depth experience with qualitative research and afforded him the opportunity to engage in new ways with students traditionally underrepresented in STEM. Roger and his team developed a research study to understand the relationship between high school and early college experiences for a group of urban students in a full-tuition scholarship program at a private engineering university. Guided by Dr. Smith, the team developed research questions and designed a research methodology to evaluate the success of the scholarship program. Initially, Roger argued for a data collection scheme that gave primacy to an online survey. Only after repeated coaxing from his instructor did Roger eventually agree to develop a semi-structured interview protocol and meet individually with students in person. The personal connection afforded by these interviews, coupled with the process of transcribing, rereading, and coding, enabled Roger and his colleagues to develop a much deeper appreciation for the unique challenges faced by students traditionally underrepresented in engineering classrooms.

Roger recounted his learning as he credited this experience with making him more aware of his position and privilege growing up in middle class, White suburbia:

> Although I was familiar with the problems faced by students in the city school district, it was eye-opening for me to speak with these students and get a first-hand account of their perspectives. I was amazed at how articulately they could describe the problems they encountered in high school and the challenges they faced in college. (Field notes, fifth semester)

For Roger, this experience became an essential element of his changing perspectives. Prior to entering the doctoral program, Roger had been teaching college students with the goal of treating all of his students equally. Never before had he been encouraged, nor had he taken the opportunity, to engage underrepresented students to discuss *their* challenges. Doing so has simply not been a component of the culture of engineering education. During a focus group session that included five doctoral classmates, Roger reflected on his engagement with the urban students of color:

> One of the things we learned [from the students we interviewed] is, if your child was treated the way some of these kids were treated by the system, you'd be marching around the schools with pitchforks and torches. The suburban parents would not have tolerated it. (Focus group, sixth semester)

Roger described what he learned from the project as "eye opening." Despite living in close proximity to an impoverished urban school district regularly in the news for failing schools, Roger was in many ways unaware of the hurdles the K-12 school system places in front of those students traditionally underrepresented in engineering.

In applying Howard's (2006) framework to Roger's two statements above, we interpreted his reflection to indicate a new awareness of diverse perspectives and an interest in broader truths. Although the transition was occurring slowly, he was beginning to focus on his understanding of culture. As such, we categorized Roger's statements as depicting an Integrationist perspective. The experience of working with urban students opened Roger's eyes in a way they had not been opened during three decades as a faculty member.

5.3.2 | A combination of influences initiated a change in perspective

Readings, classroom discussions, consistent prodding from Dr. Smith, and the opportunity to meaningfully engage with underrepresented students all shaped Roger's thinking about diversity and equity in engineering education. As it turned out, these experiences aligned with a personal experience for Roger's college-age son, which ultimately instigated a change in perspective for Roger:

> The "aha" moment for me was in the spring my son had an opportunity to do a research project at [the university where Roger's son was enrolled]. My parents never went to college. I went to college. So there's one generation change. I never would have been able to participate in research when I was in college because I worked part time to pay for things. Now he's the next generation. Because I could afford to pay his expenses, he didn't have to get a job, he could take this unpaid internship. And it gave him eight months of experience which was invaluable…. He's more privileged than me. And I'm significantly more privileged than my parents, and my parents were significantly more privileged than their parents. (Interview, second year)

For Roger, the coursework, projects, and prompting from his instructor did not seem to be enough to turn the tide of his beliefs related to privilege. It was the personal connection of his son's volunteer research situation in conjunction with those experiences that led Roger to make the connection between privilege and his own family.

Although Roger's explanation does not support a complete understanding of race or privilege, it demonstrates a shift in his perspective compared to his conceptions of privilege early in his doctoral program. Prior to the doctoral program, he recognized that not all of his students were the same, but he had never reflected on the chasm between the opportunities available to students in the wealthy suburbs and the challenges that confronted students in the nearby urban district. Never before had Roger deeply reflected on the connection between lack of success in college and disparity of preparation, cultural influences, socioeconomic background, or simply the phenomenon of being an outsider.

We interpreted Roger's statements above as depicting an Integrationist perspective when we applied Howard's (2006) White Identity framework. Roger demonstrated self-interrogation as he reflected on the generational differences experienced by his family as he adopted a "personal rather than institutional" (Howard, 2006, p. 104) perspective on race and privilege. Earlier, Roger had displayed a strong and consistent rejection to suggestions that he was privileged. Readings, reflective journals, classroom discussions, and regular arguments put forth by Dr. Smith were initially unable to penetrate Roger's galvanized belief system. It was not until Roger began to reflect on an educational opportunity available to his son and to compare his son's opportunities to those of the urban students Roger met through a research project that he began to understand the implications of privilege in his own life. This finding reinforced related findings from literature surrounding privilege in that Roger appeared to recognize only the disproportionate distribution of wealth and privilege associated with those whom Roger interpreted as having more than he. He may have been keenly aware of those with more privilege, but his awareness did not situate him within a larger continuum, which included those with less privilege.

5.3.3 | Reflecting on privilege and classroom interactions

Roger had spent three decades as a committed teacher, believing that he should treat all of his students equally, and striving to create organized and detailed materials to help his students learn. It was not surprising that early in the doctoral program, he began to consider the connections between his teaching practices and what he was now learning about students, race, and culture. During a reflective writing assignment specifically focused on culture, Roger demonstrated that he was beginning to understand his own unintended contribution to an educational environment that disadvantaged underrepresented students:

> The reality is, my version of culturally neutral is from the perspective of a White male. Even with the best intentions, there is no way to separate my cultural subjectivity from my life's experiences…. My attempts to be culturally neutral have been in fact culturally insensitive toward anyone who is not like me. Clearly, this, or any, form of culturally insensitive teaching can have a profound impact on [underrepresented students] being disenfranchised…. Hence, it is my belief that a culturally responsive curriculum and teaching practices are equally important to the [underrepresented] students to prevent their disenfranchisement as it is to the [majority] students so they understand the disenfranchisement. (Reflective journal entry, first semester)

During our ongoing interactions, we discussed national efforts to increase the long-standing underrepresentation in engineering majors with Roger. Throughout the doctoral program, Roger began to reflect more often on his own experiences as a student compared to the underrepresented students enrolled in the courses he teaches:

> I started to consider, "How would a White student feel about heading down south to attend [an] HBCU?" It's the same for a Black student coming here, but we never recognized that before. My perspective was "We're friendly, just assimilate, what's the problem?" I see things much differently now. (Field notes, sixth semester)

After experiencing challenges to his beliefs about privilege, Roger recognized, by empathizing with the other (Bakhtin, 1986/1993), that perhaps for an outsider, conforming to the dominant culture and achieving success are not as simple as he once believed. Due to the variety of experiences in the doctoral program that focused on equity and privilege, Roger began to view his students, his classroom, and the world from a different perspective. He began to recognize that his attempts at equality had unintentionally disadvantaged underrepresented students. Roger reflected on his changing belief almost apologetically as he explained "acknowledging that [we were privileged] was a bitter pill to swallow" (Interview, second year). Roger had begun to understand and reflect on his own resistance to conceptions of privilege. He shared that this recognition eventually led him to

view students differently and to seek more personal connections with all of his students. As researchers, we interpreted both of these statements by Roger as demonstrations of self-reflection and awareness. As such, we categorize some of Roger's thinking and feeling, as evidenced by these quotations, as Integrationist and moving toward Transformationist.

Important to these research findings is the understanding that Roger, like each of us, is on a journey of learning. This is evidenced by his characterization of White students attending an HBCU. Through the experiences of his doctoral program and parallel personal influences, Roger came to realize that being an outsider could create unique challenges, which may disadvantage those in the minority. He has recognized one form of cultural capital. However, it is not clear from Roger's statements that he has developed an understanding of the privilege associated with skin color or the sociocultural capital that may come with being part of an affluent, middle-class White culture. Similar to Roger's interaction with a colleague about the local urban school system, the statement above provides evidence that Roger's understanding of race, culture, and ethnicity fails to account for the advantages that come with being a member of the dominant culture (Parsons, 2005; Yerrick & Hoving, 2003).

5.3.4 | An attempt to teach through inquiry

To help build a credible account for Roger's shift in his White Identity orientation (Howard, 2006), we invited Roger to review our analysis of his beliefs and actions. We intentionally explored areas of Roger's professional actions, which appeared to us as researchers to be anchored to past beliefs. For example, we inquired if we could observe his classroom and his best efforts to transform his classroom to be more open, less didactic, more constructivist, and more culturally responsive (Gay, 2000).

As part of a goal to effectively teach to a broad range of students, Roger had created an in-class group assignment based on constructivist strategies for a first-year computer programming class. He explained his objective in the lesson was to use sorting, a concept generally familiar to the students, as an application to help them learn computer programming. He wanted to create an inquiry-based teaching activity "that my students could connect to" (Field notes, seventh semester). His intention was to create an environment that encouraged students to construct their own knowledge and drive their own learning rather than simply behaving as passive recipients. However, based on observational data, Roger's attempt to create an inquiry-based exercise was ultimately less successful than he had hoped.

Roger began the lesson we observed by briefly describing to the students what he meant by a "sorting algorithm." After the explanation, Roger introduced different types of sorting algorithms and explained which algorithms were efficient and which were not. Roger referenced a projected image to describe the exercise he wanted the students to complete. The instructions included:

- List 2–3 things that you sort (i.e., arrange or order) in your everyday life.
- Why do you sort them?
- What process do you use to sort them?

When he presented the instructions, Roger offered the class examples of socks and shirts as things the students might sort. Roger then instructed students to begin the exercise:

> Take two minutes to think about something you sort. Why order? What is the process by which you sort?

Instead of giving the students 2 minutes to think, Roger continued to speak. He told the students to follow the steps as projected on the screen. He then explained he wanted students to think about the process they would use to sort something because the computer sorts differently from a human. The students were not encouraged to work in any particular fashion. Eventually, all students worked individually. None of the students spoke. Forty-five seconds after giving the students "two minutes," and less than 30 seconds after he stopped talking, Roger broke the silence:

> Roger: [Student Name] What do you have?
> Student: Socks.

Roger immediately spoke again, asking more students "what they had." Despite Roger's intention that the students would explain "why they sort" and "what process" was used to sort, students were never given the opportunity to explain specifics of how they would sort. The answers to Roger's questions were simply one-word answers such as "socks" or "shirts"; one student offered "books." When Roger asked questions requiring more than a one-word answer, as soon as the student hesitated, Roger would answer the question himself, effectively completing the sentence for the student. Roger never gave students the

opportunity to verbalize answers to the second or third questions projected on the screen. The interaction concluded 5 min after Roger's initial question about sorting.

Roger's intention, to create an opportunity for students to construct their own knowledge, was admirable and a goal that was supported and encouraged throughout his doctoral program. However, despite these good intentions and a well-outlined plan, once he began to teach, Roger reverted to teaching strategies with which he was comfortable: Initiation/Response/Evaluation (IRE) patterns of discourse (Cazden & Beck, 2003; Sinclair & Coulthard, 1975), where the teacher is the authority in the classroom controlling the learning (Lemke, 1990). Roger did not accomplish his goal of connecting the programming assignment (a sorting algorithm) with a topic already familiar to the students (organizing things). He presumed the students' answers, and, seemingly to move the class along, did not give students the opportunity to articulate their own answers. Despite careful planning designed to address what Roger had learned about the negative impacts of teacher-centered classrooms, he struggled to successfully implement a student-centered environment.

We include this potentially contradictory piece of evidence to convey that shifting faculty beliefs about race, culture, and privilege can be difficult and unpredictable. Literature is replete with cultural studies demonstrating that such shifts are often inconsistent, arduous, and at times regressive (Bryan & Atwater, 2002; Green, 2003; Rodriguez, 1998; Rodriguez & Kitchen, 2005; Solomon, Portelli, Daniel, & Campbell, 2005; Yerrick & Hoving, 2003). Similarly, Roger's path was, and continues to be, a nonlinear journey. As researchers, we are genuinely troubled by the lack of transformation in Roger's teaching and would not offer a final placement within Howard's (2006) schema until more evidence begins to refute his actions and earlier statements regarding diversity, privilege, and intended change. Certain of Roger's beliefs, espoused at various times during his doctoral journey, reside within the Transformationist category. We have clearly described several instances where those shifts have occurred. However, the enactment of Roger's teaching illuminated the difficulty faculty encounter when attempting to modify long-held beliefs and practices.

Our findings indicate that Roger's perspectives shifted during the doctoral program. We have applied Howard's White Identity framework to Roger's own words and actions in an attempt to concisely demonstrate where and how White engineering identities may be impacted, to what extent they may be dislodged, and which dissonant events and experiences may lead to the replacement of one set of cultural beliefs with another.

While many may not consider the shift in Roger's perspectives to be transformational, as researchers seeking to promote change in the culture of engineering education, we interpret the story of Roger as one that offers hope. Roger had the opportunity to confront conceptions of his own privilege, which he initially rejected. Over time, influenced by many experiences that challenged his perspectives of equity, privilege, and race, Roger became more aware of the barriers faced by those outside the dominant culture. He began to reflect on his own contributions to the systemic marginalization of those traditionally underrepresented in engineering and his responsibility for remedying structured inequity within his own sphere of influence.

6 | IMPLICATIONS

Building on past critical cultural research in STEM communities, Roger's case study has explored some of the beliefs, predispositions, and potential biases implicit in his mind as an engineering educator. Based on our experiences in researching engineering classrooms and working closely with engineering educators, Roger's story is reflective of the beliefs and biases of many more engineering educators. The behaviors, attitudes, and norms that disadvantage certain students are deeply embedded in the culture of engineering education (Secules, Gupta, Elby, & Turpen, 2018), a culture in which Roger had been immersed for decades. Although engineering education literature has turned its attention to culture in recent decades, we believe Roger's 4-year trajectory suggests that more attention should be paid to exploring potential biases, entrenched thinking, privileged context, and the deeply human side of engineers. Like other scholars who have argued the profound effects of engineering cultural elitism on member diversity (Beddoes & Borrego, 2011; Blair et al., 2017; Hutchison-Green et al., 2008; May & Chubin, 2003; Samuelson & Litzler, 2016), we too are intent on interrogating the purported rationality and objectivity of the discipline as practiced in context.

We do not suggest engineering faculty enroll in education research focused doctoral programs. Rather, we hope engineering faculty will reflect on the experiences of Roger, a well-meaning and successful engineering educator, and compare his reflective journey with their own experiences in engineering education. Perhaps Roger's story will motivate faculty to consider engaging with education literature inside and outside the discipline. Ultimately, we hope to inspire faculty to ask reflective questions such as:

> Is it possible that my teaching practices and behaviors as a faculty member contribute to an unwelcoming environment?
> Could I modify my teaching strategies to help my students become more successful learners?

We recognize many engineering educators have neither the time nor motivation to perform extensive literature searches to reflect on how they may improve their classrooms for a diverse body of learners. Interested educators many want justification for why they should change. Others may want guidance on how they can change. Education research literature, including works cited in this article, provides excellent examples to address these desires. We encourage interested educators to consider creating a reading group or journal club with like-minded faculty who desire to learn more. Regular reading assignments and discussion groups can facilitate understanding through a grassroots effort.

The seminal work of Seymour and Hewitt (1997) in addition to several more recent works that address elitism and diversity in engineering (Beddoes & Borrego, 2011; Lichtenstein, Chen, Smith, & Maldonado, 2014; Samuelson & Litzler, 2016) should aid engineering educators in understanding the need for change. Some of the readings we might suggest to answer why include Gay (2000), especially Chapter 3, which is focused on the importance of caring and may assist faculty in becoming more inclusive and welcoming; Sheppard et al. (2008); and several from Richard Felder including (Felder, 2014).

Several prominent works including Lattuca, Bergom, and Knight (2014) provide guidance for faculty who have a desire to create student-centered classrooms. Some of the most prominent engineering research on teaching strategies has been produced by some combination of Brent, Felder, and Prince (Felder, 2006; Felder et al., 2011; Felder & Brent, 2016; Prince, 2004; Prince & Felder, 2006). Numerous works from outside engineering education that address race and cultural issues and shed light on racial identity have also been referenced throughout (Howard, 2006; McGee & Martin, 2011; McIntosh, 1989; Michael & Conger, 2009).

We adopted Howard's (2006) framework to identify influences on Roger's perspectives, perturbations which challenged him to reconsider some of his long-held beliefs about students traditionally underrepresented in engineering. Having identified specific experiences that influenced Roger's perspectives, an important next step for engineering education researchers interested in promoting cultural change is to determine if similar experiences can be effective in broadly influencing engineering educators' perspectives.

Roger's story offers insight into the culture of engineering education and potential strategies for creating an environment more welcoming to a diverse body of incoming students. Our investigation with Roger has led us to believe that no single strategy in isolation will be sufficient for shifting perspectives of engineering educators. Rather, to influence engineering educators to embrace and adopt change, a true shift in perspective will require numerous experiences over time.

6.1 | Building understanding and capabilities through educational research

Prior to entering the PhD program, Roger was admittedly unaware of the education research literature both inside and outside of engineering education. Assimilating this literature informed Roger's shift in perspective of the engineering education culture. Also, a critical component of Roger's experience included considerable prodding from Dr. Smith, his mentor and in some cases, provocateur. In the absence of a guiding force like Dr. Smith, faculty members may never leave the comfortable confines of their own insulated, privileged perspectives. Providing similar experiences for engineering faculty could be valuable in enhancing the culture of engineering education.

We believe a compelling case exists for engineering colleges to include a small cadre of engineering education researchers within faculty ranks. Appropriately trained researchers could help identify cultural aspects of the local education community that contribute to an unwelcoming environment for those traditionally underrepresented in engineering. These colleagues could serve as mentors to foster a faculty community interested in education research, improving teaching capabilities through broadening understanding of culturally responsive pedagogies (Gay, 2000; Rodriguez, 1998) and ultimately enhancing student recruitment and retention within their universities. They could be provocateurs who instigate reflection on policies, practices, and cultural norms. Current literature exploring alternative research methodologies and findings, even as closely related as science education equity research, can broaden equity discourse in important ways. New conversations emerge when engineering educators recognize the increase in student performance achieved through alternative teaching strategies, especially among those traditionally underrepresented in engineering. Argumentation, critical thinking, problem-based learning, and other constructivist approaches enhance student engagement and have been shown to broadly promote learning gains (Eddy & Hogan, 2014; Freeman et al., 2014; Prince & Felder, 2006). Engineering education researchers could facilitate this culture change through the creation of journal clubs, education research-focused seminars and colloquia, presentations by guest researchers, and collaborative education research projects that cross discipline boundaries.

To that end, engineering administrators should identify, encourage, and support engineering faculty members interested in working to diversify the student body. Recognizing the value of Critical Race interpretations of educational contexts and applying constructs implicit to Culturally Responsive Teaching (Gay, 2000), Culturally Relevant Pedagogy (Ladson-Billings, 2013), Critical Race Theory (Bell, 1995; Crenshaw, Gotanda, Peller, & Thomas, 1995; Delgado & Stefancic, 2001; Ladson-Billings, 2003),

Sociotransformative Constructivism (Rodriguez, 1998, 2015), and others might instigate reflection on teaching practices and the culture of the discipline. Each framework provides pedagogical scaffolding that values the cultural backgrounds and knowledge of all students.

6.2 | Engaging with students outside the dominant culture builds understanding and empathy

Mounting evidence supports the premise that our engineering discipline, like others, is a deeply human endeavor as enacted in context (Cech, 2014), with bias, structured power inequities, and blinders toward the recognition of the structured privilege maintained among our ranks. ASEE has argued change must occur for engineering to be more pluralistic and welcoming to diverse solutions in a complex world and workforce (Jamieson & Lohmann, 2012). Based on our investigation with Roger, we believe the engineering education community can influence this change by providing faculty the opportunity to engage differently as a part of a larger community in which they are posited. Nontraditional engagement strategies can illuminate pathways for faculty and departments to actively contribute to solutions to the long-standing trend of White-male-dominated discourse norms, which exclude or marginalize diverse perspectives.

When Roger was first provided the opportunity to engage with urban students, he was strongly curious about the lack of diversity at his institution, but staunchly resistant to repeated suggestions by Dr. Smith to invoke qualitative methods to explore his questions. Not until Dr. Smith insisted upon face-to-face interviews with underrepresented students in the community and a rich qualitative analysis to build credible accounts from ethnographic data did Roger began to see his work, his stance, and his surroundings in different ways. Similarly, Roger was originally content with his beliefs that he and his son held "no special privilege" in society and that he had "earned everything he had." He believed that urban students could "achieve the same if they worked harder at it" and that engineering educators should "treat all students equally." He believed the scope of the diversity problem was outside of his influence because you "can't fix what's in the home." Other traditionally prepared faculty, who seek to engage in engineering education equity research, will likely harbor similar resistance.

Roger participated in a research project, which required him to personally interview university students who had attended urban high schools. He had the opportunity to interview multiple students and read, analyze, and code transcriptions from the interviews of several other urban students. The stories these students told caused Roger to reflect on his life and the experiences of his son. It was only following this face-to-face engagement with students from the local urban school district that his own privilege, and that of his son, became apparent to him. After engaging with Black youths and listening intently to their narratives of struggling to overcome obstacles of poorly resourced schools, Roger began to reflect on how he may act differently in his faculty role and actively move his institution toward making engineering more welcoming and achievable for local Black youth. Having a college-age son also seemed to be an important point of comparison for Roger. The juxtaposition of the two contexts caused Roger to reflect on the starkly different circumstances. Faculty from the dominant culture who compare and contrast the life experiences and opportunities available to their own children compared to those of students from outside the dominant culture may react similarly to Roger.

Participating in K-12 outreach is a common practice for many engineering faculty members. Building on these practices, we encourage more meaningful opportunities for engineering educators to interact, communicate, and learn with K-12 urban students. Doing so could help more engineering educators begin to understand that not all students arrive at college with the same middle class, Advanced Placement focused set of experiences. Such opportunities could include team teaching with K-12 educators, interviewing urban students as part of educational research, or simply engaging in extended observations of K-12 classrooms. These efforts could propagate the notion that learning and capability can be measured beyond standardized exams and that learning approaches vary starkly across contexts. It is our hope and expectation that these opportunities would help engineering faculty value the prior knowledge and experience of a diverse student body and begin to appreciate the need for alternative teaching strategies in engineering classrooms.

6.3 | Application of Howard's framework

We argue the use of the White identity model has the potential to enable engineering change agents to create culturally adapted interventions (Helms, 1990) to meet the specific needs of faculty in a supportive and understanding manner. Like Roger, other White engineering faculty members may have considered neither systems of oppression nor how they themselves have experienced privilege. Having rare and often only tacit interactions with people of color, many engineering educators may be entirely unaware that their interactions can exacerbate existing problems with historical meaning. Through this work,

we seek to support a praxis of creating safe spaces where engineering faculty develop a positive White identity (Michael & Conger, 2009) and are positioned to engage critically and reflectively in creating an inclusive and diverse engineering community. In so doing, we hope to expand the conversation toward nurturing engineering departments to become collaborative communities that welcome underrepresented groups historically marginalized from engineering, thereby recognizing the benefit of a diverse engineering population and the strengths diversity offers to both academic study and engineering practice.

We would like to highlight that our interpretation of Roger is built upon a long tradition of research that emphasizes and values reflection (Dewey, 1933) both in practice and on practice (Schön, 1983). In our role as STEM education ethnographers, we have a great luxury of being able to study teaching and teachers, to dive deeply into sociocultural frameworks, and to interpret many forms of data as a part of our vocation. Most engineering faculty who teach at the university are committed to their research and rarely rewarded for their teaching accomplishments (Jamieson & Lohmann, 2012). We call for more academic leaders to provide engineering educators with time and resources to transform their practices to build cultural responsiveness into their curricula, pedagogy, and assessments.

Engineering education researchers agree that engineering educators need to become more reflective about their teaching practice (Adams & Felder, 2008; Lattuca et al., 2014). Tinkering with, minimizing, or rationalizing male dominant norms runs counter to efforts to expand the gender, cultural, linguistic, and other diversity among future engineering students. While society lauds engineers for considering, testing, and revising a wide range of solutions to the technical problems they encounter, engineer educators have not widely engaged in the same careful and diligent reflection about their educational practice. The problems engineering students are typically required to solve do not necessarily engage the same kind of professional reflection recognized by scholars who have studied reflective practice (Adams, Turns, & Atman, 2003; Dewey, 2012; Jonassen, 2014; Schön, 1983; Shulman, 1986).

We were able to identify within Roger's longitudinal account specific events and prompts that influenced his notion of privilege in ways we interpret as affecting his long-term perspectives of race and privilege. For nearly three decades, Roger had been content to look at those who had achieved privilege and status beyond his own to inform his perspective of privilege. After direct challenges of literature, discussions, and research projects in the doctoral program, his awareness and beliefs changed relative to students traditionally underrepresented in engineering. Roger agrees that working closely with underrepresented students influenced a shift in his perspective. Therefore, we argue for the creation of more opportunities for engineering faculty to meaningfully engage with students from traditionally underrepresented populations. Engaging with underrepresented K-12 students, in conjunction with reflecting on teaching strategies and literature related to diversity and inclusion, will help engineering faculty understand their own privilege and improve the culture of engineering education for all students.

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