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"Man, I am a Black Engineer": The Co-development of Transformational Resistance and Engineering Identity

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Abstract

Many societal inequalities are inexorably linked to engineering and technology that are pervasive and transformational in our society. Engineering students from underrepresented backgrounds may care about addressing social inequalities but may have a challenging time identifying with the historically white, masculine culture of engineering that emphasizes technical aspects of engineering. We used the lenses of transformational resistance and engineering identity to explore ways that engineering identity, social identity, and identification with social justice may be co-developed in engineering students. We used a single case study methodology to examine the counternarrative of Andre, an Afro-Latino male undergraduate computer engineering student who took an engineering course that integrated issues of racial inequality. We found that Andre's social identity was not only related to but was inseparable from his engineering identity in that he identified as a "Black engineer." His experiences as a Black person caused him to have a personal connection to his critiques of social oppression, and he learned how he might have a role in working toward social justice through engineering. Thus, for Andre, identification with engineering, race, and social justice were all related. The findings of this study may have implications for how institutions leverage students' social justice resources that they bring into engineering, integrate issues of social justice into engineering education, and broaden perspectives of engineering such that the field might appeal to a wider variety of students. Results highlight the value and utility of integrating issues of social inequality into engineering education for potentially increasing interest, persistence, and representation in the field of engineering.

Introduction

A significant amount of research has focused on engineering identity [1], demonstrating how engineering identity contributes to engineering students' educational and professional outcomes [2]–[4] including increased persistence in engineering [5], [6]. Specifically, engineering students are more likely to stay in engineering with increased engineering identity (e.g., [7], [8]), and are more likely to leave the field if they do not identify with engineering (e.g., [9]–[11]). While there is variation among definitions of engineering identity [12], frameworks often use a professional identity perspective that involve a relationship between some aspects of the self and the profession of engineering [13], [14]. Gender and racial identities are commonly studied alongside engineering identity, as these social identities can greatly impact the engineering identities of women and students from historically racially minoritized backgrounds [1]. Prior frameworks, however, often do not integrate students' concerns for social justice (see [1], [13], [14] for systematic reviews) even though research has shown that students of color often choose STEM majors to address issues of inequity [15]–[18].

In order to fill this gap, we used a single case study methodology [19] to explore ways that engineering identity, social identity and identification with social justice may be co-developed. Given that traditional engineering cultures have been shown to play a negative role on students' social justice concerns [15], [17], [18], [20]–[23] we chose to examine the counternarrative of an Afro-Latino undergraduate engineering student who took a newly developed engineering course that integrated issues of racial inequality. As measures of

engineering identity continue to be increasingly used in models of engineering education, findings from this study have implications for refining understandings of how engineering students relate to their engineering training and profession along with issues of social (in)justice, social identity, and community.

Background

Engineering identity

Undergraduate engineering identity is widely studied (e.g., [3], [4], [24], [25]), and is theorized to be composed of three constructs: performance/competence, interest, and recognition (e.g., [5], [26]–[32]). Performance is defined as social performance of engineering practices, while competence is an understanding and knowledge of the topic that is often less visible than performance [26]. Interest refers to interest in learning and performing engineering [27]. Finally, recognition is being seen as an "engineering person" by "significant" others and by oneself [26]. We expand on prior studies of undergraduate engineering identity to explore ways in which engineering identity may be related to social identity and identification with social justice.

Social identity in STEM contexts

Social identity (i.e., race, ethnicity, gender, socioeconomic status, religion, ability, sexual orientation, immigration status) plays an important role in engineering contexts. For example, while recognition is an essential component of an engineering identity [33], individuals from underrepresented groups in STEM may struggle to be recognized as competent. The dominant epistemology of "white, middle-class, masculine norms" devalues other ways of knowing and perpetuates the unwelcoming culture of STEM departments where meritocracy and competition reign [34]. Racial/ethnic identity is central for many Black students in engineering [35], [36] however, research has shown how racial/ethnic minoritized students often negotiate their racial and cultural identities against traditional STEM disciplinary cultures [18], [23]. The racism faced by Black engineering students is often not overt, but is subtle and pervasive [37]. Students are more likely to switch out of engineering and other technical majors when their identity does not align with the culture of the program or field [38]. Thus, racial and gender identities may be primary factors in negotiating identity and expectations in engineering (e.g., [39]–[41]).

Social Justice Concerns Among Engineering Students

Generally, research examining large datasets has shown that undergraduate engineering students are less likely than undergraduate students in other fields to believe that an individual can change society, to describe themselves as socially concerned, or to engage in promoting racial understanding or social action [20], [22], raising concerns about the training of engineering students. Although there have been changes to undergraduate engineering education including the addition of goals of "making a difference" and "social relevance" [42]–[45], more recent studies have continued to show concerning outcomes for engineering students [15], [17]. Prior studies do, however, reveal important differences in STEM students' social justice values by race/ethnicity [15], [17]. These studies have shown that Black and Latinx students in particular often negotiate these values and motivating interests against the dominant engineering culture that devalues these concerns, illuminating how these students largely develop their social concerns without critical departmental/disciplinary support (e.g., [21], [36], [46]). However,

there has been less of an examination of how students' social justice concerns in relation to their racial/ethnic identity *and* engineering identity may develop within the context of an engineering classroom that may support this development rather than devalue it.

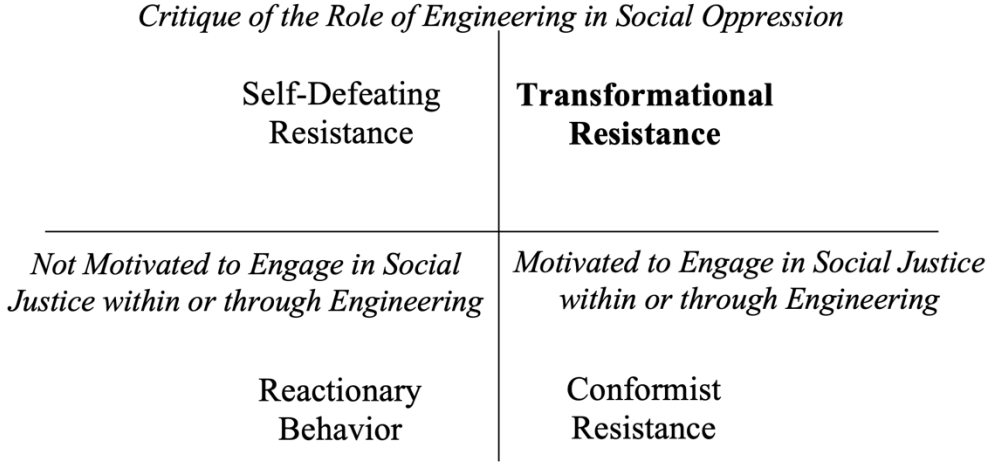
Framing

Transformational Resistance in the context of engineering

In this study, we examine resistance to the dominant narrative of engineering as white, middle-class, and masculine through the dimensions of critique of social oppression and motivation to engage in social justice [47], [48]. We adapt Solorzano & Bernal's [49] definition of resistance for examination of resistance in the context of engineering, as shown in Figure 1.

Figure 1

Four types of Resistance in an Engineering Context (Adapted from Solorzano & Bernal [49])



Boundaries between these four behaviors are flexible and blurred; manifestations of resistance may differ greatly between individuals [49]. Additionally, different behaviors of a single individual may fit into different quadrants. This framework for resistance is not intended to assign more or less value to students whose resistance falls in these different quadrants or to describe any deficiencies in students. We recognize that not all engineering students have equal resources (i.e., time, effort, knowledge, finances) to engage in transformational resistance and that students alone are not responsible for transforming the culture of engineering. The behaviors in each of the quadrants are explained in the following section, with a reminder that a variety of circumstances could affect the kind of resistance a particular student demonstrates.

Reactionary behavior, which is not actually a form of resistance, may take the form of a student acting out against or challenging authority figures for no particular cause [49]. Adapted to an engineering context, reactionary behavior is when a students' behavior demonstrates no critique of the role of engineering in social oppression and is not motivated to address social injustices within or through engineering. An example of this is a student who acts out or behaves poorly in class or a lab without recognizing and critiquing the social conditions that make them behave in this disruptive manner.

Self-defeating resistance occurs when a student engages in notions of resistance that are not transformational (does not help transform their oppressive status in the long run) and often re-create oppressive conditions [49]. For example, in the context of engineering, an engineering student who chooses to leave college because they have critiques of social oppression within engineering but not because they are motivated to change the social injustices within or through engineering, behaves in a way that does not help to transform engineering in a meaningful way and can be destructive to oneself or others by not finishing college.

Conformist resistance occurs when a student engages in superficial solutions which may help themselves and others achieve better conditions, but do nothing to address the structural inequities causing the problem [49]. In the context of engineering, conformist resistance is behavior that seeks to address social injustices within or through engineering but has no critique of the role of engineering in social oppression. An example is an engineering student who believes that the best way to help reduce the number of students leaving engineering is to offer tutoring for their peers so that they can better adapt to the culture of engineering [48]. While this student demonstrates social justice motivation, they engage in a superficial solution within existing social systems and social conventions that does not deal with structural causes of the problem and has no critique of engineering [48]. Although tutoring supports the students being tutored to be successful in the current system, because the student does not critique or challenge the social inequities causing students to leave, the behavior is conformist rather than transformational.

Transformational resistance occurs when a students' behavior demonstrates a critique of oppressive systems as well as a desire for social justice [50], offering the greatest capacity for social change [49]. We argue that in engineering, this is behavior that is motivated to address social injustice within or through engineering and has a critique of the role of engineering in social oppression. Transformational resistance can take internal or external forms. Internal resistance appears to conform to norms, but individuals are consciously engaged in critique of oppression. Importantly, internal transformational resistance is different from conformist resistance in that the student does take on a social justice agenda, although their behavior may not openly demonstrate this motivation for social justice [50]. In the context of engineering, a student engaged in resisting stereotypes about their gender or race in engineering by choosing to stay in engineering (despite their recognition of the injustices within the field) demonstrates internal transformational resistance. In fact, persistence in an engineering major may itself be a form of internal resistance [50]. In contrast, external transformational resistance appears with more overt, non-conforming behavior that overtly operates outside of tradition. For example, engineering students engaged in external transformational resistance might advocate for changes to university policies or the culture of engineering through protests or political writing. Because internal resistance may be subtle, external resistance is often romanticized while the more subtle form of internal transformational resistance may go unnoticed or be ignored [49].

Because the boundaries between these four behaviors can be blurred, it is important to understand an individual's intentions as well as the impact of their behavior. For example, a woman in engineering may believe that the best way to combat the low number of women in engineering is to become a mentor for other women in the white, male space of engineering. While this student demonstrates a social justice motivation, their intent matters in considering whether such behavior is conformist versus transformational. If the mentor tries to prepare their

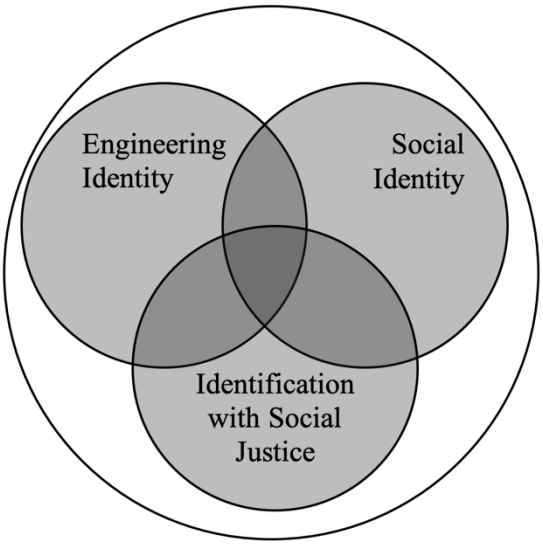
peers to be better situated to succeed within the current system, they would exhibit conformist resistance. But if the mentor focuses on teaching mentees about and challenging the white, male culture of engineering, they would exhibit transformational resistance.

Identification with social justice

In this study, we adapt frameworks for examining students' multiple identities [51], [52] to examine undergraduate engineering students' engineering identity and social identity, alongside a conceptual identification with social justice (Figure 2). We put forth a conceptual identification with social justice as a method of operationalizing students' concerns about societal oppression and motivation to address social injustices as an integral part of how they describe themselves and who they are, which we posit relates to the form of resistance in which a student engages. Specifically, a student who identifies more strongly with a social justice orientation may be more likely to engage in transformational resistance or conformist resistance while a student who does not identify with social justice ideas may engage in self-defeating resistance, reactive behavior, or may not engage in resistance at all. In this study we use resistance (specifically, the dimensions of *critique of the role of engineering in social oppression* and *motivation to address social injustices within or through engineering*) to define identification with social justice and to gain insight into a student's identification with social justice in the context of engineering.

Figure 2

Conceptual Framework for Studying Engineering, Social, and Social Justice Identities



The framework may not apply the same way to each individual. For example, one individual may have a strong gender identity that greatly overlaps with their identity as an engineer and their identification with social justice. For this individual, the social identity bubble might be larger, and shown to overlap a great amount with engineering and social justice identities. In contrast, an individual whose gender identity is less central and does not influence their identity as an engineer might be represented by a smaller social identity bubble that does not intersect with the engineering identity bubble. This fluid framework might also be used to

represent themes in identities across individuals. Using this framework, we integrate frameworks for resistance [49] and engineering identity [51] to consider the ways in which engineering identity and identification with social justice may be co-constructed in engineering, and the relationship that social identity may have with these identities.

Research question

The purpose of this study is to tell the counternarrative of an Afro-Latino, male undergraduate engineering student who was enrolled in a course that integrated engineering and social justice. Counternarratives are a tool for revealing experiences that are not often brought into focus and for analyzing and challenging prevalent dominant narratives [53]. Counternarratives are essential to contradicting the dominant white, male, middle class [34] narratives about engineering and may also demonstrate the specific challenges that individuals from minoritized populations may face in STEM. Critical literature examining race and gender in STEM education commonly uses counternarratives as a tool to explore the perspectives of students who come from historically marginalized backgrounds (e.g., [37], [39], [54]–[56]). The experience of the participant in this study is a counternarrative to the majority white culture of engineering. We use this participant's counternarrative to examine the concepts of transformational resistance, engineering identity, and social identity, and how these concepts relate to each other in the context of engineering. Specifically, we address the following research questions: Do engineering identity, social identity, and identification with social justice relate in this student's story and how does he describe those relationships? We take an asset-based approach to examining this engineering student's understanding and concern for social justice with the goal of empowering students to continue to concurrently grow in their engineering identity, motivation to engage in social justice, and critiques of social oppression.

Methods

A qualitative case study approach was used to explore the experience of a Black, Latino, male, undergraduate computer engineering student with the pseudonym Andre [57]. Instead of looking for large themes across many participants, we chose to use a single case study to forefront Andre's unique story and to describe in detail overlap (or absence of overlap) between engineering identity, social identity, and identification with social justice in his story. This study was approved for human subjects research by the Institutional Review Board at the institution, and Andre gave informed consent to participation in all aspects of this study.

Context and participants

A discussion-based engineering elective course that comprehensively integrated content focused on social justice and racial equity, which we call by the pseudonym Engineering and Race in the USA, was the context for the selection of our participant. The goal of the course, taught by a Black, female associate professor in an engineering department, was that students learn from one another and think critically about whether and how systemic racism is enabled by engineering and technology, and where race matters are embedded in socio-technical systems (i.e., systems made up of people and technology). The 15 students enrolled in the Fall 2020 course were graded on their participation in class discussions, their leadership of the class discussion for a single class period, weekly reflective essays in which they synthesize and react to the assigned readings, and their final paper and presentation on race matters in the socio-

technical system of their choice. Engineering and Race in the USA was selected for study due to the unique content and the first author's familiarity with the course and the professor, which led to increased access to data and participants [58].

Engineering students whose racial identities have been historically marginalized and first-generation students enroll in this elective course in higher proportion than is representative of the university at large. Specifically, students were 19% Asian, 25% Black or African American, 19% Hispanic, 31% White, and 6% multi race. Half the class was female and the other half were male. The course was taught at a mid-Atlantic university at which 24% of undergraduate engineering students are Asian, 5% are Black or African American, 6% are Hispanic, 50% are White, and 6% are multi race. An additional 3% of undergraduate engineering students are international students, while the race of 7% of students is unknown.

Our participant, whom we gave the pseudonym Andre, was enrolled in Engineering and Race in the USA during the Fall 2020 semester. Importantly, Fall 2020 was the first semester that this course was being offered at the university, and the course (and many other courses at the university) was taught virtually, which may have impacted the experience. We interviewed Andre in Fall 2021, one year after he was enrolled in the course. We chose to examine Andre's story, specifically, because of the easy rapport he had with the interviewer that led to detailed and thoughtful descriptions of both identity and resistance. Additionally, we felt that it was important to tell Andre's story of being a Black engineer, in particular, due to the focus of both the course and our research on issues of race and social justice in engineering.

Data collection

The primary data source was a one-hour long interview with Andre, which was used to learn about Andre's social identity, engineering identity, perceptions of social justice in engineering, and critiques of social oppression. The narrative-style interview asked Andre to talk about the experiences he had in the course and relevant experiences prior to taking the course, and asked questions that explored Andre's engineering identity and his perceptions of what it means to be an engineer, critiques of social oppression, interest in social justice, and perceived changes in these dimensions from taking the course, in line with the frameworks. The interview included questions such as:

- What do you know about social justice issues related to engineering?
- Do you see yourself as an engineer? Why or why not?
- Do you believe science or engineering departments should be involved in addressing social/racial injustice? Why or why not?

The interview questions were developed by the team of four researchers based on the frameworks for transformational resistance and engineering identity, an interest in racial and social justice in engineering, and participant context. An initial list of interview questions was drafted through multiple discussions. These initial questions were modified after three students were interviewed to improve the overall flow of the interviews and to elicit greater conversation around social identity. Andre was then interviewed using the finalized interview questions. Andre had no relationship to the interviewer prior to this study.

A second source of data consisted of artifacts of Andre's work from the course, including final presentation slides, a final essay, and 11 weekly written reflections. These artifacts provided additional insight into Andre's perceptions of social justice in engineering and his critiques of social oppression, and the weekly essays in particular provided data about these topics across the semester Andre took the course. This second data source was used to triangulate the interview data and strengthen the validity of the findings [19].

Analysis

We chose to take a holistic coding approach [59], [60] to analyze the interview transcript. We coded for broad themes in the interview, and then zoomed in to examine how the themes related. First, four researchers read the interview transcript and listened to the audio file to become familiar with the participant and the content of the interview. Then, each researcher individually conceptually coded the transcript at a high level for the themes of engineering identity, social identity, critique of social oppression, and social justice motivations (Table 1), in alignment with the frameworks, and particularly looked for where these concepts intersected. Each coder then summarized and reflected upon the main ideas that Andre brought up in the interview and the intersection of the high-level concepts.

Table 1

Thematic Codes

Code	Definition	Examples from Andre
Engineering Identity	What makes someone an engineer; how one relates to the role of an engineer and is formed by the characteristics and expectations of that role.	"From high school to college, whenever you hear 'engineer' you just think numbers, numbers…"
Social Identity	Race, ethnicity, gender, socioeconomic status, religion, ability, sexual orientation, immigration status, and how these intersect to inform who you are.	"When I go into classes, you might be the only Black person in the class. Luckily for me, in my major we've had seven other Black computer engineers […] so I had a community that I look out of."
Motivated by Social Justice	Student expresses that they are motivated by an interest in social justice	"Because I know definitely Black people in [University] have opened doors for me, so I want to do the same thing for the next generation of new engineers, or just Black engineers in general."
Critique of Social Oppression	Student expresses a critique of social oppression or societal inequalities	"…you'd have to acknowledge that there are issues in engineering in the first place, and doing that means you have to confront just the systemic racism that's already embedded in engineering and other forms of STEM."

The four researchers then met to discuss their thematic coding and the intersections of themes expressed by the participant. Through their discussion, the researchers established the form of resistance in which Andre reported to be engaged and detailed the ways that his ideas about engineering were shaped by critique of social oppression and social justice motivation. The first author then created an analytic memo [61] based on the discussion to provide a detailed summary of the findings from the participant, while also winnowing the data [57]. The other three researchers revised the memo to further validate the findings. This memo was a starting draft for the findings reported in this manuscript.

After the researchers had generated an initial memo from Andres's interview data, two of the researchers analyzed the artifact data collected from Andre, again looking for the same themes used in the holistic coding analysis (Table 1). The two researchers independently examined each artifact, specifically looking for passages of writing that aligned with the themes noted in the interviews, while also searching for any disconfirming evidence as a strategy for strengthening the validity of the findings from the interview data. After this independent analysis, the two researchers met to discuss their independent findings in order to reach agreement concerning the findings from this data source. In that discussion, the researchers also expanded the analytic memo to include new ideas and additional evidence of ideas from the interview data. Again, the other researchers read and revised this memo to strengthen the validity of the findings.

Finally, a summary of the final memo was sent to Andre for member checking to strengthen the validity of the findings. Andre had no critiques of the memo and agreed with our summary of his thoughts.

Researcher positionality

The authors of this work firmly believe in the importance and relevance of social justice and civic responsibility in the field of engineering and engineering education. The authors recognize the many ways that engineering influences our society, and the ways that engineering can perpetuate systemic racism in society. Due to the focus of this work on identity, and particularly social identity, it is important that we, the authors, describe our own identities and acknowledge how our own identities influence our interactions with the participant and the data. The first author is a white woman with degrees in chemical and systems engineering. The other authors include two white women with backgrounds in chemistry and higher education administration in an engineering school and one Latino man with a background in applied mathematics and higher education. While the authors all have STEM backgrounds, we acknowledge that we cannot share in the intersectional experience of being a Black person and an engineer. The participant's social identity and engineering identities are uniquely his own and we have done our best to report on his experiences using his own words wherever possible to authentically and meaningfully reflect Andre.

Findings

We examined the story of a single participant with the pseudonym Andre. Andre was, at the time of the interview, a fourth-year undergraduate engineering student studying computer engineering. He had family members who worked as engineers which made him feel like engineering was a viable career option. He signed up to take Engineering and Race in the USA

because he thought that it would be an interesting course given that he had not previously had many opportunities to talk about race and how it overlaps with technology in his engineering training. Before taking the class he "didn't know anything really" about how racial or social justice issues related to engineering and technology. Andre's social identity informed his critiques of social oppression. He perceived social justice to be part of an engineering identity, and his social identity also shaped both his engineering identity and his views on social justice. These connections will be explored in the following sections.

Andre's description of his social identity and his personal experiences with racism

Mid semester, Andre reflected in a weekly essay about his complex racial identity and how it related to the constraints of society. Andre wrote in the essay that he "felt comfortable with being Afro-Latino." Based on the manner in which the U.S. recognizes race and ethnicity, answering questions about race was sometimes challenging for Andre. He wrote in his reflection:

> I would ask my mom whether I should fill in Black or Hispanic knowing that I was Afro-Latino. […] Looking back at it now, I can only assume that she knew that my Blackness would overshadow any other aspects of my identity in the eyes of the American society.

Andre did not bring up the complexities of his racial identity in the interview, choosing to focus solely on his racial identity as a Black person.

Andre's racial identity related to his first-hand experiences with racism. For example, in his interview, Andre talked about a Black friend who told him that he "looked Black on the outside but really acted white on the inside." This confused Andre, who was already struggling to understand his complex racial identity, and made him question if his Black peers saw him as white. Andre said in the interview:

> I felt at times I wasn't Black enough to be accepted by the Black community so parts of me wanted to be white. But knowing how Blackness is seen in the United States, any effort I put towards that goal would never be enough.

In addition to the complexities of being Afro-Latino, Andre also described complexities in the ways that he was identified as Black and the fact that he could not change his Blackness or how his Blackness would be perceived in society. In his interview, Andre said that, as a Black person, he could never ignore social oppression. Andre believed that the presence of racism was the same within engineering contexts as it was elsewhere in his life. He said of himself and his Black peers, "I think we've just been exposed to [racism] all our lives, so it's not like it's any different talking about it in engineering versus talking about it in [any other] class. You're still going to be experiencing it." Andre described being exposed to a certain amount of social oppression first hand, and how he felt a certain amount of acquiescence concerning social oppression in his life as a Black person, whether or not he is in engineering contexts. Andre also described how he and his Black peers have, over the course of time, accepted that they are often the only Black students in the room and that racial issues relevant to their experiences were not discussed in classes.

Relationship between social identity and identification with social justice

In his weekly reflections, Andre provided examples of his understanding of the role of engineering in social oppression through examples of: providing access to clean water, the prison industrial complex, providing healthcare solutions, accessing quality housing, voter suppression, and algorithms used to make decisions about peoples' lives. While his first weekly reflection included little to no language critiquing how engineering may contribute to racial oppression, every weekly reflection that followed did include critique of the role of engineering in perpetuating oppression. For example, Andre wrote in his second assignment:

> Engineering has always been part of holding up systems of oppression from the very beginning of slavery using whips, chains, and other tools. […] The role of engineering in US prison industrial complex can be seen before individuals reach prison. The lack of resources in public schools in impoverished neighborhoods such as transportation and lack of adequate technology in addition to harsh school policies have been a factor in the rise of mass incarceration. Just how technology has been used to keep prisoners in prison, the lack of technology has contributed to prisons gaining more prisoners.

Throughout the remaining reflective essays, Andre also made many personal connections to the material. For example, when reflecting on a documentary about slavery in the fifth essay, Andre wrote:

> It is scary to see how white fragility has remained common between Solomon's time and my time. Though the consequences for disrupting this white fragility are vastly different, the effect is the same. Bit by bit, breaking down the identity of the Black person until nothing is there.

The personal connections that Andre made between social oppression and his own life demonstrate his critiques of the ways in which society has allowed for racism and discrimination to continue. His interview and written assignments also demonstrate a sense of his motivations to work toward a more just society. For example, when reflecting on voter suppression, Andre wrote:

> I have had arguments with a couple of my Black friends about why they don't want to vote and how even if they did, it would be pointless. For me personally, I believe that for young Black Americans I think we should not only vote so the country can hear our voice but also to respect and show appreciation to all of the Black people who were blocked from voting, threatened for voting, and even killed for voting.

This quote demonstrates Andre's personal connection to issues of social oppression in voting, his motivation to take on his civic responsibility to vote, and his understanding of how this social issue is historically related to his racial identity.

All of the examples of social oppression in relation to engineering that Andre chose to discuss in the interview also related to his social identity as a Black person. For example, the ways in which Black people are often viewed on the internet through search algorithms struck a personal cord for Andre:

> "I learned […] how influential society has been in terms of, for me, being a Black person and seeing how Black people are seen on the internet. I think they had an article about Black girls, and how if you search that back in the early 2000s, pornography would come up, which is wild to me, versus now it's obviously changed. The fact that those two words were associated with that type of content, that means […] the initial thoughts of it was just like anything that's Black and women, it's obviously just sexualized.

Because Andre identified as a Black person, he chose to give this example when asked about how social justice relates to engineering. Particularly, at the beginning of this quote, Andre highlighted how this specific example of Black women being sexualized also impacted him as a Black person through the broader issues surrounding "how Black people are seen on the internet." Andre was able to give a specific example of how engineering contributes to a larger social issue that he is personally connected to through his racial identity.

In another example, Andre discussed racial bias in software used by police officers. This was a "personal experience" due to Andre's identity as a Black person and because his father was a police officer. He said:

> My father, he's a police officer, and talking to him about what's so bad about using machine learning software and all that, and I'm telling him like, 'If you have bad data, then you're going to get bad results, that's it. […] you're just going to create a cycle of just areas that are crime infested even though they really might not be, but because you've pointed that out back in the 1980s or the '90s when there was definitely some racism going on, then now we're going to still see that same thing is happening and it's just going to be a continuous cycle.'

This quote demonstrates that Andre had an understanding of how engineering can perpetuate societal racism, and had engaged in conversations about these issues with his family. A weekly essay contained an expanded description of Andre's conversation with his father. Andre described his father as a Black man, living in a time when Black men "were treated blatantly like second and even at times third class citizens," who witnessed the "countless times that police have hurt the Black community." Despite this, Andre wrote that his father was "defensive" of the belief that the technology was not biased, "but rather the people using the technologies are using the technology in a biased manner." Andre wrote that it bothered him that his father denied the systemic issue. Andre said "I don't understand why putting on a badge [caused] such a change in perspective about the police, especially when they at one moment in their life have faced injustice from the police." Andre allowed his social identity to influence his critiques of social oppression, and was bothered that his father did not hold those same critiques despite similar experiences.

Further, Andre wrote about his belief that his father, due to his status as a police officer, had some amount of power to offer critique of the police force. Andre expressed a desire for his father to use this power to engage in social justice work and help bring equity to policing. He wrote in a weekly reflection:

> But if the minorities that are enlisted into the police force agree with what the general majority of the police force believes in, then the manner of technology being integrated

> will be swift and without any backlash due to using diversity as a cover of confirmation rather than a check for equality.

These reflections about the conversation with his father demonstrate the personal nature of Andre's critiques of social oppression and, to a lesser extent, his engagement in conversations about working towards social justice.

Additionally, Andre was critical of how issues of social oppression can be viewed and acted upon in engineering. He spoke about how the similar acceptance of social oppression in engineering contexts further exacerbated the lack of discussion of racial injustice in engineering:

> Man, we really don't talk about [social issues] at all. We definitely have social issues as Black people here, and then engineering over there, but they're not together. We talk about it, but we don't talk about it together sometimes. And I think that's just on our part- just the acceptance. […] I don't feel like it's good enough.

Andre demonstrated an understanding of the role of engineering in social oppression, and of how his racial identity contributed to his understanding of social oppression. This understanding also related to his critiques of the way social oppression, and racism in particular, is viewed within engineering. Andre's social identity was related to the way that he identified with social justice in engineering contexts through critique of social oppression.

Relationship between engineering identity and identification with social justice

Andre reported that his views on social justice greatly informed his perceptions of engineering and that understandings of social justice issues were essential to being an engineer. He said:

> If you're an engineer that doesn't know social justice issues, why are you an engineer? You're supposed to be the building blocks of society, but if you don't intake what society wants or it needs, then your use is really minimal.

This comment demonstrates that, to Andre, motivation to engage in social justice issues can be the same motivation behind engaging in engineering. This connection highlights the ways that Andre's views of engineering were entwined with a motivation to engage in social justice. Andre's weekly essays and final project provide additional insights into Andre's perceptions of the ways engineering relates to social justice. In one weekly essay, Andre wrote:

> As engineering is a tool which can be used to meet certain goals, we can change our perspective and think of possible ways we can re-engineer the system to benefit and help those who have been oppressed. Before expanding on how to re-engineer the system, we must understand that the system won't simply change by 're-engineer the system,' but rather changing the social perspective of race in this country. If the United States upholds the idea that people of color are a threat to society then there isn't any type of re-engineering that will fix the system. With this being understood, we can begin to view possible options for how to re-engineer the system.

Andre not only demonstrated an insightful understanding of social issues and their relationship with engineering, but also critiqued the quick fix that might be embraced by engineers at the

expense of more nuanced understandings. Andre instead advocated for larger societal changes that require an honest investigation of the goals of engineering and the history of race in America and its modern implications.

Further, Andre said in the interview that engineers should be curious about things beyond the technical- things like history, law, and society. To Andre, the connection to society should be a focus of engineering, as he said in his interview, "like making sure as an engineer that you could see that your calculus class is somehow related to something that's happening in society that's a real-world issue. I feel like that should be a main thing." For Andre, engaging in "real world issues" or "social justice issues" was a bridge between the technical aspects of engineering, and engineering's usefulness in society. Thus Andre's engineering identity was greatly informed by his being motivated to engage with social justice.

Relationship between engineering identity and social identity

Andre's engineering identity was also greatly informed by his identity as a Black person. At first, he struggled to answer the interview question "do you see yourself as an engineer?" He initially responded "I don't know, I don't know." Andre's identity as a Black person, and the concern for social oppression that accompanied it, meant that he did not describe himself as a "stereotypical engineer" because "a stereotypical engineer is so focused all the time about their engineering, or they're always coding. I don't feel always like that, I worry about social issues." Upon further reflection, Andre identified himself not as an engineer broadly, but as a "Black engineer," specifically. He said:

> Man, I am a Black engineer. No matter how technical, how good I am, whatever capabilities I have, I will always have to face that social issue of being Black in America, and whatever that comes with that.

Social issues related to his Black identity felt inescapable for Andre, and this was true no matter how competent Andre felt as an engineer. This reflection was part of a larger reflection about how engaging in Engineering and Race in the USA "made it more prevalent" that he was a Black engineer. He described how the "connections [he] had with the stories that were told or the content [he] was reading" caused him to accept that he could not separate his racial identity from his engineering identity. Not only did his racial identity cause him to have to face issues of being Black in America himself, but it also meant that he brought a perspective of caring about social issues into his role as an engineer.

Andre went on to define being a "Black engineer" in more detail. To him, being a "Black engineer" meant additional self-doubt, questioning from peers, pressure to represent all Black people, and constantly being in white spaces. He said:

> As a Black engineer, you have to just face a lot of hesitation, like are you supposed to be there? A lot of doubt from other computer classmates, like, 'Oh, do you really know this? Are you actually smart?' And then also the pressure- people look at you like you're like the spokesperson for all Black people, like, 'Oh yes, could you talk about why Black people are struggling?' Then too, it's just being in white spaces all the time. I feel like [Institution] engineering is just such a white space, like everywhere I go is just white people. […] In my major I have a little small space that I know that is all Black people.

> Outside of that, I feel like it's just consistently trying to prove myself and telling people that I'm worth it, that I'm supposed to be here.

In this definition, Andre outlined how being a Black engineer is comprised of the struggle of questioning your identity as an engineer (through hesitation and being in white spaces) while your identity as a Black person defines you (through pressure to represent Black people). For Andre, engineering identity was inseparable from his social identity as a Black person, which he described added many challenges to being an engineer.

Relationship between engineering identity, social identity, and identification with social justice

Andre's final presentation and final essay, both titled "Why an introductory course of Data and Algorithms as being biased would help combat bias in the Engineering Field," argued for the combination of social and technical issues in engineering on the basis that critical thought about social issues is essential to being an engineer. He chose to examine this topic for his final project because of his belief in the connection between engineering and social change. The following excerpt from his final paper describes his motivation:

> If the future is engineering, only a small amount of people will be controlling the future and where it will lead. Furthermore, the same engineers that don't want to take classes about diversity, language, and history because it too much "information", are the same people who will be building the future systems, most likely taking the biased ideas they had from high school into the work setting without any opportunity for those ideas to be criticized. Honestly, this showed why engineers need to take the time to understand the cultural, social, economic, and political impacts their technologies have when revealed to the world, especially if no one else does.

Andre's argument that engineers must be exposed to information that challenges what they know and take time to understand social implications of their work was tied to Andre's larger argument about the integration of technical and social aspects of engineering, specifically through engineering courses that focus on these topics. This argument echoed ideas that he expressed in his interview, as he said about numbers:

> Engineers need to be taught that numbers are not simply just numbers, especially as engineering becomes more of a foundation in the technologies that are used in daily life. [...] If a generation of engineers are taught to be more critical of their own foundations and include social awareness in their projects, their ideas may have a greater impact on the communities that their projects are aimed at.

Andre viewed an engineering course that integrates social issues as a way to reduce bias in the technologies that are used in daily life and impact communities through exposing engineers to the social impacts of their technical work. This argument demonstrates the relationships between Andre's perceptions of engineering identity, social identity, and identification with social justice through the exploration of the ways that he, as a Black engineer, understood how separating technical and social aspects of engineering perpetuate racial bias in society.

Andre stated in his interview that he viewed the separation of technical aspects of engineering, what he called "numbers", from their influence on society as a way of making engineering "easier for white people to digest, so that they don't have to worry about those

issues." He went on to say that this was because to integrate social issues "you'd have to acknowledge that there are issues in engineering in the first place, and doing that means you have to confront just the systemic racism that's already embedded in engineering and other forms of STEM." Implicit in Andre's statement is the idea that the separation of technical and social skills in STEM perpetuates systemic racism by allowing systemic racism to continue unconfronted.

Another example of the overlap between Andre's perceptions of engineering identity, social identity, and identification with social justice is through his discussion, in both interview and artifact data, of the counterspace of Black engineers and the larger community of people of color in which Andre found community. Due to the challenges of being a Black person in the white space of engineering, Andre described how he sought out connections with other Black engineers who understood his experiences and these challenges. Andre reported in the interview that this community of Black engineers was foundational to the formation of his engineering identity and was a "support group" to Andre throughout his degree. Andre wrote in a weekly essay that he has not had "bad experiences" at his university due to "staying in mostly POC [People of Color] spaces." Andre could be a Black engineer who was motivated by social justice in this space. With relation to his identity specifically, he wrote that he felt comfortable in these POC spaces because he did not feel "the need to prove my Blackness to anyone." Andre demonstrated that it was important for him to embrace his Black identity, which he felt empowered to do in "POC spaces" despite the white culture of engineering. He wrote that the "POC space" was:

> Space in which I can maintain my Blackness in a sea of primarily engineers. Though I still admit that when I am in white spaces with no other Black people, I do tend to place my some of my Blackness in the backseat, I have gotten better with expressing my complete identity in any space that I am in.

This POC space was significant to Andre because it related to his reflections on social justice more broadly, and particularly to his written reflection on slavery and the erasure of Black culture. He wrote:

> Even at this position that I am in, I am still not free. It makes me mad to know that all the culture that Black people have is being stolen [...] So my hope is for the future one day these communities of color can live in peace and maintain its history without the fear of being overtaken and rebuilt into something that wasn't made for them.

For Andre, engaging in this POC space and embracing and living out his identity as a Black person was an act of resistance against this history of social oppression.

In his interview, Andre reflected that the course "put the idea of helping other people more in the front of what I want to accomplish, like made that more of an important value in my engineering career." And Andre described thinking about helping other people of color in his interview, specifically:

> I think with my degree, I want to try to open doors that aren't opened up for other Black people or POCs, basically, because I know definitely Black people in [University] have

> opened doors for me, so I want to do the same thing for the next generation of new engineers, or just Black engineers in general or POC engineers, anything.

Again, Andre was greatly influenced by the community of Black engineers with whom he was connected. These connections inspired him to want to build connections for others.

In summary, Andre's social identity as a Black person greatly overlapped with his social-justice oriented view of engineering, and greatly shaped how Andre viewed engineering and his role in engineering. He also understood the potential impact that he could have on future Black engineers.

Limitations

There are several notable limitations to this study. This work is limited in scope to provide a more detailed account of the experience of a single participant. While the findings from Andre may not be transferable to the experiences of engineering students at other universities or those of engineering students broadly, these specific findings are important in that they further illuminate the experiences of a Black engineer. Additionally, Andre was non-randomly solicited through his participation in a course focused on racial matters in engineering. Andre, who chose to sign up for this elective course, may have more strongly identified with social justice than is representative of undergraduate engineering students broadly.

A final limitation is that the interview captured Andre's views at a single moment in time, but engineering students' views on identity and social justice may be developing over time. While we used course artifacts to provide some insights into Andre's views across the semester, longer-scale impacts of the course remain unexamined. Future research can examine engineering students' views on social justice and identity longitudinally over multiple semesters in order to examine growth and gain insight into the ways that these views are transformed throughout an undergraduate engineering curriculum.

Discussion

Andre's story provides a counternarrative to the common misconception that STEM is neutral or that social justice does not have a role in STEM [62]. Andre's story also provides insights into the challenges of being Black in engineering at a predominantly white institution. The use of a case study to examine Andre's counternarrative allowed us to center Andre's voice in an effort to allow him to tell his story through our exploration of his forms of resistance and the ways in which we interpreted how his social identity, engineering identity, and identification with social justice may interact.

Social identity and engineering identity

Despite being asked in the interview about various aspects of his social identity and how these domains intersect, Andre focused solely on his Black identity. In parallel to his reflection on his mother saying that American society would allow his blackness to overshadow other aspects of his social identity, he himself overshadowed other aspects of his multifaceted identity in favor of focusing on his Black identity. Research demonstrates that this may be common for people of color with otherwise dominant identity domains, as one's identification with a social identity that is targeted tends to make that identification the most psychologically powerful and

salient [63]–[65]. As a result, we have deep insights into how Andre's Black identity related to his engineering identity, but little to know insights into how his Latino identity may have shaped engineering identity in intersectional ways.

Andre's social identity was not only related to the way he identified as an engineer, but was entirely inseparable from his identity as an engineer, or rather his identity as a "Black engineer." This study expands on prior literature that indicates that racial identity and engineering identity may be related (e.g., [39]–[41]) to demonstrate the ways that racial and engineering identities may be inseparable for certain students (e.g., [35], [66]). Andre's counternarrative of navigating a white space as a Black engineer further demonstrates how the social oppression to which Black engineers may feel personally connected might motivate their use and understanding of engineering. Andre's perception that his white classmates' were able to ignore social injustices demonstrates a danger of the limited development of students' sense of responsibility concerning social issues in STEM education (e.g., [15], [17], [20], [22], [67], [68]). Specifically, limited development of social responsibility may lead to the isolation of Black students. Because the racism faced by students in higher education is often not overt [37], a lack of emphasis on social responsibility in engineering education can perpetuate systemic racism and isolation of Black students.

Social justice in engineering

Findings concerning the relationship between Andre's social identity and his motivation to engage in social justice issues through engineering align with prior work which suggests that the lived experiences of individuals from historically underrepresented groups in STEM may shape the goals of these individuals and impact how they value working for social change [17]. This research also demonstrates the potential value of leveraging social justice motivation and understandings of social oppression that students bring with them into engineering programs in order integrate these social justice understandings into defining what it means to be an engineer. Future research is needed to examine resources related to social justice that students might bring to engineering and the ways in which instructors might build upon these assets to strengthen students' resistance and engineering identity.

Andre's form of resistance

Initially, Andre may have had critiques of social oppression without being motivated by social justice, as he said that he did not know much about social justice related to engineering before taking the Engineering and Race in the USA course. Thus, Andre may have been exhibiting self-defeating resistance [49, p. 317]. However, Andre's story is one of change because Andre himself described moving from looking out for his own success as a Black engineer to seeing the importance of helping other Black engineers. As Andre began to feel motivated by social justice, in combination with his continued critique of social oppression, Andre's form of resistance began to move towards transformational resistance [49, p. 319]. This was no longer self-defeating resistance because Andre did demonstrate a social justice agenda. Specifically, Andre demonstrated internal transformational resistance, where his behaviors appeared to conform to the norms of engineering as a successful engineering student in an accredited engineering program, but he was consciously engaged in a critique of social oppression through taking the class and spoke about being motivated by social justice in that he demonstrated a desire to help others navigate the white space of engineering [49, p. 324]. Andre

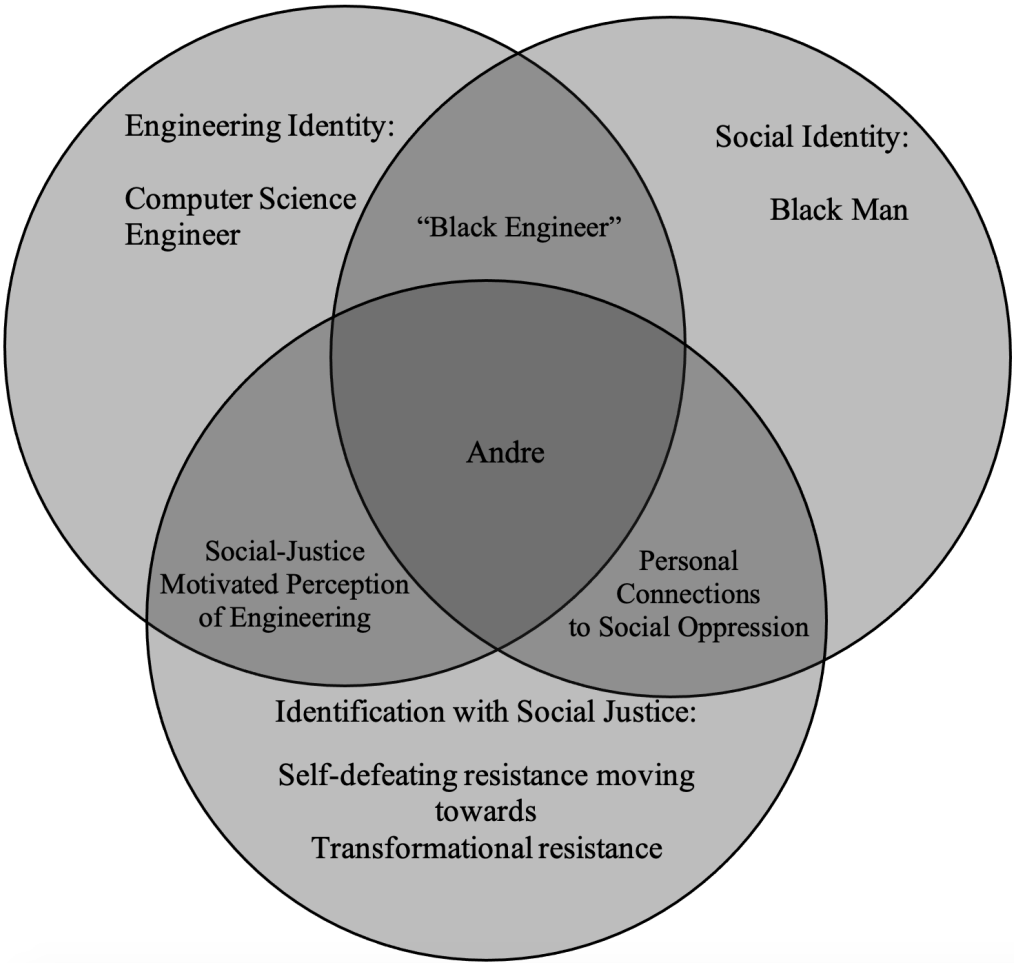
did not display external transformational resistance because he did not describe any behavior or desire to overtly go against the norms of engineering [49, p. 325].

Relationship between engineering identity, social identity, and social justice

Andre's story offers insight into how social justice motivation and critique of social oppression intersect with an engineering identity. For Andre, social, engineering, and a changing identification with social justice were observed to overlap. Namely, Andre's social identity as a Black person informed his critiques of social oppression, and thus his identification with social justice, in that he had personal connections to the social oppression of Black people that he experienced, witnessed, and learned about (Figure 3).

Figure 3

Andre's Overlapping Engineering, Social, and Social Justice Identities



Next, Andre's identification with social justice informed his engineering identity in that Andre viewed understandings of social oppression and social justice motivations as key elements of being an engineer, and believed that social justice could be used to make the technical aspects of engineering useful in society. Additionally, Andre's social identity was inseparable from his engineering identity in that he viewed himself as a "Black engineer" (Figure 3). Thus, Andre's

social, engineering, and social justice identities were all interconnected in that Andre's social identity as a Black person greatly overlapped with his social-justice oriented understanding of engineering, and greatly shaped how Andre said that he intended to use engineering towards social justice oriented goals. Specifically, Andre expressed his desire to support other Black engineers and for larger changes to happen in the culture of engineering in line with a social justice agenda (Figure 3). Through Andre's counternarrative, we were able to begin to describe relationships between engineering, social, and social justice identities.

Critique of the separation of social and technical skills

Andre's story lends support to calls for the importance of integrating the technical aspects of engineering with the development of students' sense of social responsibility (e.g., [15], [20], [22], [67], [68]). Andre openly criticized the separation of social and technical skills in his engineering experience, in line with prior research that has shown this separation to be prevalent in engineering (e.g., [62]). He also connected the devaluing of social aspects of engineering (e.g., [69], [70]) to perpetuating the whiteness of engineering. Specifically, he pointed out how separating the technical aspects makes engineering easier for white people to digest because it allows them to ignore social issues and their responsibility in social issues. Andre also said that in his experience, engineering students from racial identities that have been historically marginalized often want these social aspects integrated into engineering, which is supported by prior research suggesting that individuals from historically underrepresented groups in STEM may be motivated to engage in STEM with the goal of working for social change [17]. Thus, integrating social issues into engineering content may support the goals of individuals from historically underrepresented groups in engineering. This is in line with previous research that considers STEM education as a way to empower students whose racial identities have been historically marginalized (e.g., [26], [68], [71]), while also strengthening the sense of social responsibility in all engineering students. A true socio-technical engineering education in this way would benefit not only Black engineers and other engineers of Color, but engineers broadly.

The call to integrate issues of racial and social justice into engineering curricula relates to our descriptions of the relationship between engineering, social, and social justice identities. Social and technical aspects of engineering must not be separated in undergraduate engineering programs just as, for some students, their social and technical (engineering) identities cannot be separated. This is in line with prior work that suggests that the white, male, middle class culture of STEM education may hinder efforts to instill a sense of responsibility concerning social issues in students [67]. Our findings demonstrate the importance of integrating social and technical aspects of engineering in order to support the success of all students, because the current culture of de-valuing social aspects of engineering does not support students like Andre who, due to the integral nature of his racial identity with his engineering identity, cannot ignore social justice issues.

Significance

This study used transformational resistance and engineering identity as lenses to consider how engineering identity and identification with social justice may be co-constructed in an undergraduate engineering program. It is the goal of this work to empower engineering students to be civically and socially engaged in their problem solving and understanding of engineering. The findings of this study have implications for institutions and engineering instructors, as well

as implications for persistence and representation of engineering students and professionals. Findings of this study may also have implications for how institutions leverage students' social justice resources that they bring into engineering, integrate issues of social justice into undergraduate engineering programs, and broaden perspectives of engineering such that the field might appeal to a wider variety of students. The ways that engineering students are supported by instructors and institutions to incorporate social justice into their engineering identity might empower engineering students to affect social change. This study may help scholars better understand how social justice motivation and critique of social oppression intersect with engineering students' definitions of engineering and views of themselves as engineers. Results may highlight the value and utility of integrating issues of social oppression into engineering education for potentially increasing student interest, persistence, and representation in the field of engineering.

References

[1] S. L. Rodriguez, C. Lu, and M. Bartlett, "Engineering identity development: A review of the higher education literature," *International Journal of Education in Mathematics, Science and Technology*, vol. 6, no. 3, pp. 254–265, 2018, doi: https://doi.org/10.18404/ijemst.428182.

[2] B. M. Capobianco, B. F. French, and H. A. Diefes-Du, "Engineering identity development among pre-adolescent learners," *Journal of Engineering Education*, vol. 101, no. 4, pp. 698–716, Oct. 2012.

[3] H. M. Matusovich, B. E. Barry, K. Meyers, and R. Louis, "A multi-institution comparison of students' development of an identity as an engineer," presented at the 2011 American Society of Engineering Education Annual Conference & Exposition, Vancouver, BC, 2011. doi: https://doi.org/10.18260/1-2--17351.

[4] K. L. Tonso, "Teams that work: Campus culture, engineer identity, and social interactions," *Journal of Engineering Education*, vol. 95, no. 1, pp. 25–37, Jan. 2006, doi: https://doi.org/10.1002/j.2168-9830.2006.tb00875.x.

[5] K. L. Meyers, M. W. Ohland, A. L. Pawley, S. E. Silliman, and K. A. Smith, "Factors relating to engineering identity," *Global Journal of Engineering Education*, vol. 14, no. 1, pp. 119–131, 2012.

[6] O. Pierrakos, T. K. Beam, J. Constantz, A. Johri, and R. Anderson, "On the development of a professional identity: engineering persisters vs engineering switchers," in *39th IEEE Frontiers in Education Conference*, San Antonio, TX, 2009, pp. 1–6. doi: https://doi.org/10.1109/FIE.2009.5350571.

[7] T. Beam, O. Pierrakos, J. Constantz, A. Johri, and R. Anderson, "Preliminary findings on freshmen engineering students' professional identity: Implications for recruitment and retention," presented at the 2009 American Society of Engineering Education Annual Conference & Exposition, Austin Texas, 2009.

[8] L. S. Nadelson *et al.*, "Am I a STEM professional? Documenting STEM student professional identity development," *Studies in Higher Education*, vol. 42, no. 4, pp. 701–720, Apr. 2017.

[9] E. J. McCave, J. Gilmore, and K. Burg, "Engineering and science student preparedness for research: Exploring the connections between student identity and readiness for research," presented at the 2014 American Society of Engineering Education Annual Conference & Exposition, Indianapolis, IN, 2014.

[10] C. Owen and D. Rolfes, "Communication class size and professional identity," presented at the 2015 ASEE Annual Conference and Exposition, Seattle, Washington, Jun. 2015. doi: 10.18260/p.23705.

[11] K. L. Tonso, "Engineering Identity," in *Cambridge Handbook of Engineering Education Research*, A. Johri and B. M. Olds, Eds. New York: Cambridge University Press, 2013, pp. 267–282.

[12] A. D. Patrick and M. Borrego, "A review of the literature relevant to engineering identity," presented at the 2016 American Society of Engineering Education Annual Conference & Exposition, New Orleans, Louisiana, 2016. doi: https://doi.org/10.18260/p.26428.

[13] J. R. Morelock, "A systematic literature review of engineering identity: Definitions, factors, and interventions affecting development, and means of measurement," *European Journal of Engineering Education*, vol. 42, no. 6, pp. 1240–1262, Nov. 2017, doi: https://doi.org/10.1080/03043797.2017.1287664.

[14] K. L. Tonso, “Making science worthwhile: Still seeking critical, not cosmetic, changes,” *Cult Stud of Sci Educ*, vol. 9, no. 2, pp. 365–368, Jun. 2014, doi: 10.1007/s11422-012-9448-5.
[15] J. C. Garibay, “STEM students’ social agency and views on working for social change: Are STEM disciplines developing socially and civically responsible students?,” *J Res Sci Teach*, vol. 52, no. 5, pp. 610–632, May 2015, doi: 10.1002/tea.21203.
[16] F. Herrera and G. Kovats Sánchez, “Curando La Comunidad [Healing the Community]: Community-Centered STEM Identity,” *Journal of Hispanic Higher Education*, pp. 1–16, Jan. 2022, doi: 10.1177/15381927211069543.
[17] J. C. Garibay, “Beyond traditional measures of STEM success: Long-term predictors of social agency and conducting research for social change,” *Res High Educ*, vol. 59, no. 3, pp. 349–381, May 2018, doi: 10.1007/s11162-017-9470-2.
[18] E. O. McGee, “Devalued black and latino racial identities: A by-product of stem college culture?,” *American Educational Research Journal*, vol. 53, no. 6, pp. 1626–1662, Dec. 2016, doi: 10.3102/0002831216676572.
[19] R. K. Yin, *Case study research and applications*, 6th Ed. Thousand Oaks, CA: Sage, 2018.
[20] A. W. Astin, “Diversity and multiculturalism on campus: How are students affected?,” *Change*, vol. 25, no. 2, pp. 44–49, 1993.
[21] E. McGee and L. Bentley, “The equity ethic: Black and Latinx college students reengineering their STEM careers toward justice,” *American Journal of Education*, vol. 124, no. 1, pp. 1–36, Nov. 2017, doi: 10.1086/693954.
[22] L. J. Sax, “Citizenship development and the American college student.,” in *Civic responsibility and higher education*, T. Ehrlich, Ed. Phoenix, AZ: Oryx Press, 2000, pp. 3–18.
[23] M. C. Tran, F. A. Herrera, and J. Gasiewski, “STEM Graduate Students’ Multiple Identities: How can I be me and be a scientist?” National Association of Research on Science Teaching, 2011.
[24] M. Eliot and J. Turns, “Constructing professional portfolios: Sense-making and professional identity development for engineering undergraduates,” *Journal of Engineering Education*, vol. 100, no. 4, pp. 630–654, Oct. 2011, doi: https://doi.org/10.1002/j.2168-9830.2011.tb00030.x.
[25] J. Major and A. Kirn, “Engineering identity and project-based learning: How does active learning develop student engineering identity?,” presented at the 2017 American Society of Engineering Education Annual Conference & Exposition, Columbus, Ohio, 2017. doi: https://doi.org/10.18260/1-2--28255.
[26] H. B. Carlone and A. Johnson, “Understanding the science experiences of successful women of color: Science identity as an analytic lens,” *Journal of Research in Science Teaching*, vol. 44, no. 8, pp. 1187–1218, 2007, doi: https://doi.org/10.1002/tea.20237.
[27] A. Godwin, “The development of a measure of engineering identity,” presented at the 2016 American Society of Engineering Education Annual Conference & Exposition, New Orleans, Louisiana, 2016. doi: https://doi.org/10.18260/p.26122.
[28] Z. Hazari, G. Sonnert, P. M. Sadler, and M.-C. Shanahan, “Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study,” *Journal of Research in Science Teaching*, vol. 47, no. 8, pp. 978–1003, 2010, doi: https://doi.org/10.1002/tea.20363.

[29] A. Godwin and W. Lee, "A cross-sectional study of engineering identity during undergraduate education," presented at the 2017 American Society of Engineering Education Annual Conference & Exposition, Columbus, Ohio, 2017. Accessed: Sep. 13, 2019. [Online]. Available: https://peer.asee.org/27460
[30] K. L. Meyers, M. W. Ohland, A. L. Pawley, and C. D. Christopherson, "The importance of formative experiences for engineering student identity," *International Journal of Engineering Education*, vol. 26, no. 6, pp. 1550–1560, Dec. 2010.
[31] A. D. Patrick, M. Borrego, and A. N. Prybutok, "Predicting persistence in engineering through an engineering identity scale," *International Journal of Engineering Education*, vol. 34, no. 2, pp. 351–363, Mar. 2018, doi: https://doi.org/10.15781/T2ZC7SB9J.
[32] A. Prybutok, A. D. Patrick, M. Borrego, C. C. Seepersad, and M. Kirisits, "Cross-sectional survey study of undergraduate engineering identity," presented at the 2016 American Society of Engineering Education Annual Conference & Exposition, New Orleans, Louisiana, 2016. doi: https://doi.org/10.18260/p.26610.
[33] A. Godwin, G. Potvin, Z. Hazari, and R. Lock, "Identity, critical agency, and engineering: An affective model for predicting engineering as a career choice," *Journal of Engineering Education*, vol. 105, no. 2, pp. 312–340, Apr. 2016, doi: https://doi.org/10.1002/jee.20118.
[34] A. L. Pawley, "Universalized narratives: Patterns in how faculty members define 'engineering,'" *Journal of Engineering Education*, vol. 98, no. 4, pp. 309–319, Oct. 2009, doi: 10.1002/j.2168-9830.2009.tb01029.x.
[35] C. Mobley, C. E. Brawner, R. Brent, and M. K. Orr, "The Centrality of Black Identity for Black Students in Engineering," in *Proceedings of the CoNECD Conference*, Virtual Conference, 2021, p. 21.
[36] C. Newman, "Engineering success: The role of faculty relationships with African American undergraduates," *J Women Minor Scien Eng*, vol. 17, no. 3, pp. 193–207, 2011, doi: 10.1615/JWomenMinorScienEng.2011001737.
[37] B. A. Burt, A. McKen, J. Burkhart, Hormell, and Knight, "Black men in engineering graduate education: Experiencing racial microaggressions within the advisor–advisee relationship," *The Journal of Negro Education*, vol. 88, no. 4, pp. 493–508, 2020, doi: 10.7709/jnegroeducation.88.4.0493.
[38] B. A. Danielak, A. Gupta, and A. Elby, "Marginalized identities of sense-makers: Reframing engineering student retention," *J. Eng. Educ.*, vol. 103, no. 1, pp. 8–44, Jan. 2014, doi: 10.1002/jee.20035.
[39] L. Avraamidou, "'I am a young immigrant woman doing physics and on top of that I am Muslim': Identities, intersections, and negotiations," *J Res Sci Teach*, vol. 57, no. 3, pp. 311–341, Mar. 2020.
[40] K. A. Robinson, T. Perez, A. K. Nuttall, C. J. Roseth, and L. Linnenbrink-Garcia, "From science student to scientist: Predictors and outcomes of heterogeneous science identity trajectories in college.," *Developmental Psychology*, vol. 54, no. 10, pp. 1977–1992, Oct. 2018, doi: 10.1037/dev0000567.
[41] K. A. Robinson, T. Perez, J. H. Carmel, and L. Linnenbrink-Garcia, "Science identity development trajectories in a gateway college chemistry course: Predictors and relations to achievement and STEM pursuit," *Contemporary Educational Psychology*, vol. 56, pp. 180–192, Jan. 2019, doi: 10.1016/j.cedpsych.2019.01.004.

[42] L. J. Shuman, M. Besterfield-Sacre, and J. McGourty, "The ABET 'Professional Skills' - Can They Be Taught? Can They Be Assessed?," *Journal of Engineering Education*, vol. 94, no. 1, pp. 41–55, Jan. 2005, doi: 10.1002/j.2168-9830.2005.tb00828.x.
[43] H. Zandvoort, "Preparing engineers for social responsibility," *European Journal of Engineering Education*, vol. 33, no. 2, pp. 133–140, 2008.
[44] Committee on Public Understanding of Engineering Messages, National Academy of Engineering, "Changing the conversation: Messages for improving public understanding of engineering," National Academies Press, Washington, D.C., 2008.
[45] R. F. Vaz, "Connecting science and technology education with civic understanding: A model for engagement," *Peer Review*, vol. 7, no. 2, pp. 13–16, 2005.
[46] L. J. Charleston, "A qualitative investigation of African Americans' decision to pursue computing science degrees: Implications for cultivating career choice and aspiration," *Journal of Diversity in Higher Education*, vol. 5, no. 4, pp. 222–243, 2012.
[47] H. Giroux, "Theories of reproduction and resistance in the new sociology of education: A critical analysis," *Harvard Educational Review*, vol. 53, no. 3, pp. 257–293, Sep. 1983, doi: 10.17763/haer.53.3.a67x4u33g7682734.
[48] H. Giroux, *Theories and resistance in education*. South Hadley, MA: Bergin and Garvey, 1983.
[49] D. G. Solorzano and D. D. Bernal, "Examining transformational resistance through a critical race and latcrit theory framework: Chicana and Chicano Students in an urban context," *Urban Education*, vol. 36, no. 3, pp. 308–342, May 2001, doi: 10.1177/0042085901363002.
[50] S. L. Rodriguez, B. E. Bukoski, K. J. Cunningham, and A. Jones, "Critiquing Oppression and Desiring Social Justice: How Undergraduate Latina Students in STEM Engage in Acts of Resistance," *Journal of Women and Gender in Higher Education*, vol. 13, no. 3, pp. 251–267, Sep. 2020, doi: 10.1080/26379112.2020.1838297.
[51] A. M. McAlister, S. C. Lilly, and J. L. Chiu, "A framework for examining engineering doctoral student role identity," presented at the 2021 ASEE Annual Conference & Exposition, Virtual Conference, 2021. [Online]. Available: https://peer.asee.org/36580
[52] A. Kaplan and J. K. Garner, "A complex dynamic systems perspective on identity and its development: The dynamic systems model of role identity," *Developmental Psychology*, vol. 53, no. 11, pp. 2036–2051, 2017, doi: https://psycnet.apa.org/doi/10.1037/dev0000339.
[53] R. Delgado, "Storytelling for oppositionists and others: a plea for narrative," *Michigan Law Review*, vol. 87, pp. 2411–2441, 1989.
[54] M. C. Beckmon, J. L. Huff, N. W. Sochacka, J. Walther, and B. Okai, "Negotiating identity as a response to shame: A study of shame within an experience as a woman in engineering," presented at the 2019 American Society of Engineering Education Annual Conference & Exposition, Tampa, FL, Jun. 2019.
[55] A. J. Gonsalves, "Exploring how gender figures the identity trajectories of two doctoral students in observational astrophysics," *Physical Review Physics Education Research*, vol. 14, no. 1, 2018.
[56] M. S. Ross, J. L. Huff, and A. Godwin, "Resilient engineering identity development critical to prolonged engagement of Black women in engineering," *J Eng Educ*, p. jee.20374, Jan. 2021, doi: 10.1002/jee.20374.
[57] J. W. Creswell and J. D. Creswell, *Research design: Qualitative, quantitative, and mixed methods approaches*, Fifth edition. Los Angeles: SAGE, 2018.

[58] G. Thomas, “A typology for the case study in social science following a review of definition, discourse, and structure,” *Qualitative Inquiry*, vol. 17, no. 6, pp. 511–521, Jul. 2011.
[59] I. Dey, *Qualitative data analysis: A user-friendly guide for social scientists*. London: Routledge, 1993.
[60] J. Saldaña, *The coding manual for qualitative researchers*, 2nd ed. Los Angeles: SAGE, 2013.
[61] D. Lee, A. M. McAlister, K. Ehlert, and C. Faber, “The use of analytical memo writing in a mixed methods grounded theory study,” presented at the 49th IEEE Frontiers in Education Conference, Cincinnati, OH, 2019. doi: https://doi.org/10.1109/FIE43999.2019.9028469.
[62] E. A. Cech, “The (mis)framing of social justice: Why ideologies of depoliticization and meritocracy hinder engineers’ ability to think about social injustices,” in *Engineering Education for Social Justice*, vol. 10, J. Lucena, Ed. Dordrecht: Springer Netherlands, 2013, pp. 67–84. doi: 10.1007/978-94-007-6350-0_4.
[63] S. Hurtado, A. R. Alvarado, and C. Guillermo-Wann, “Thinking about race: The salience of racial identity at two- and four-year colleges and the climate for diversity,” *The Journal of Higher Education*, vol. 86, no. 1, pp. 127–155, 2015, doi: 10.1353/jhe.2015.0000.
[64] A. Hurtado, P. Gurin, and T. Peng, “Social identities-A framework for studying the adaptations of immigrants and ethnics: The adaptations of mexicans in the united states,” *Social Problems*, vol. 41, no. 129–151, p. 24, 1994.
[65] B. D. Tatum, “Talking about race, learning about racism: The application of racial identity development theory in the classroom,” *Harvard Education Review*, vol. 62, no. 1, pp. 1–24, 1992.
[66] P. Murrell, “Identity, agency, and culture: Black achievement and educational attainment,” in *The Sage Handbook of African American Education*, L. Tillman, Ed. Thousand Oaks, CA: Sage, 2009, pp. 88–106.
[67] J. Beckwith and F. Huang, “Should we make a fuss? A case for social responsibility in science,” *Nature Biotechnology*, vol. 23, no. 12, pp. 1479–1480, 2005.
[68] E. Gutstein, *Reading and writing the world with mathematics: Toward a pedagogy for social justice*. New York: Routledge, 2006.
[69] G. Downey, “Are engineers losing control of technology? From ‘problem solving’ to ‘problem definition and solution’ in engineering education,” *Chemical Engineering Research and Design*, vol. 83, no. 6, pp. 583–595, Jun. 2005, doi: 10.1205/cherd.05095.
[70] R. Stevens, A. Johri, and K. O’Connor, “Professional Engineering Work,” in *Cambridge Handbook of Engineering Education Research*, A. Johri and B. M. Olds, Eds. New York: Cambridge University Press, 2013, pp. 119–138. doi: 10.1017/CBO9781139013451.010.
[71] A. Calabrese Barton, “Science education in urban settings: Seeking new ways of praxis through critical ethnography,” *J. Res. Sci. Teach.*, vol. 38, no. 8, pp. 899–917, 2001, doi: 10.1002/tea.1038.