Breaking Barriers in Engineering Teams: Exploring the Experiences of African American Female Students

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Abstract

In undergraduate engineering programs, team projects are often used to provide students with comprehensive hands-on experiences on collaborative teams. These projects can present difficulties to all students, but implicit biases and microaggressions can make them particularly challenging to those who are underrepresented or marginalized in engineering. Many studies show that women are often undervalued and have negative experiences on team projects, but little work has been done at the intersection of race and gender. This study begins to bridge that gap by exploring the undergraduate teaming experiences of self-identified African American females in engineering.

To understand this phenomenon, we analyzed interviews with nine participants who self-identified as African American and female collected as part of a phenomenological study of African American students' experiences on engineering teams. Previous analyses have examined the experiences of participants who identify as male; in this analysis, we focus on the participants who identified as female. To frame the original study, we drew upon intergroup contact theory (ICT) as a sensitizing concept. Intergroup contact is defined as the direct face-to-face interaction among members of different groups (such as race or gender) and the resulting psychological responses. ICT identifies key conditions that enable positive contact between members of different races and genders in a group.

For this exploratory analysis, we included all participants in the larger study who identified as African American and female; all were full-time undergraduate students enrolled in an engineering course with a team project. The nine participants represent a range of years in school and engineering majors. Data collection followed a three-interview sequence and included questions about participants' background, their team project, and their reflections on the teaming experience, respectively. In this paper, we present our initial exploration of the data focused on the reflective third interview.

To analyze the data, we followed basic qualitative practices for first and second cycle coding, including 1) reviewing all nine interview transcripts to establish a base understanding, 2) creating participant profiles to include basic information, 3) re-reading each interview and noting significant statements about the participants' experiences, 4) comparing these noteworthy and significant experiences to determine emergent codes, 5) creating a preliminary codebook that defined each code and provided examples, and 6) grouping the codes into categories to better understand the participants' experiences. Although we did not use ICT as an a priori coding framework, it

did serve as a set of sensitizing concepts for the original study and thus was used in the interpretation of our findings.

Analysis of these categories yielded several expected concepts, as well as several novel concepts regarding African American female engineering students' teaming experiences. The emergent categories of findings are related to the importance of good communication, imbalance of skill sharing and task delegation, and effects on engineering self-perception.

Most participants described positive teaming experiences that allowed them participants to enhance their self-perception as engineers. Likewise, participants who had negative teaming experiences were more likely to have a decreased self-perception of themselves as engineers. The implications of these and other results are discussed throughout the paper. Suggestions are also provided for faculty who facilitate team projects to bridge the gap between research and implementation into practice.

Introduction

Teamwork is continually recognized as a key skill in engineering education and practice and has even become a requirement for engineering programs to receive accreditation [1]. Team projects have been shown to help students learn communication skills, creativity, cultural competence, and project management, among other skills [2]. As a result, undergraduate engineering programs often incorporate team projects to help students apply their knowledge and to prepare them for the collaborative nature of most industry work [3]. These projects are present in first-year engineering courses, senior capstone projects, and more recently, second and third-year courses [4, 5, 6]. These team interactions demonstrate practical knowledge skills by tasking groups of students with complex problems. While research on student engineering teams is extensive, few studies to date have explored how students' intersecting identities impact their experiences on teams, particularly at the intersection of race and gender. (Note: in discussing gender, we use the terms "man/men," "woman/women," "non-binary," and "trans-men/women" for general discussions; when referencing previous research, we use the term used by the researchers; when referencing our participants, we use the term "female" because, as discussed in the Methods section, it was the term used in the original screening survey; we recognize that subsequent developments in research related to gender make this term a marked limitation of the research. The screening survey also used the term "African American" to identify participants; for more general discussions, we use "Black or African American.")

With respect to gender, a substantial body of research shows women as a whole are often isolated and underutilized on engineering team projects [7, 8, 9, 10], even though they improve group collaboration and increase overall collective intelligence on teams [11]. More recently, work has begun to emerge that considers the intersections of gender with other demographic categories such as race [12, 13]. For example, a study of African American males on student teams noted the importance of personal interaction with their teammates in increasing comfort and shaping their perceptions of cross-race interactions, but the study also found that such interactions were not common or consistent [14]. However, more work is needed at the intersection of race and gender to garner a more robust understanding of how the undergraduate engineering teaming experience can be improved for individuals with intersecting marginalized identities.

The present work contributes to this need by examining the experiences of African American females on undergraduate engineering teams at a single predominantly White institution (PWI). We focus here on African American females because the consistently low number of this marginalized population in engineering points to systemic environmental barriers [15, 16] such as rejection and lack of belonging in the predominantly White, male field [17]. While studies of race and engineering have historically highlighted multiple systemic barriers for Black or African American students broadly linked to the fields' predominant Whiteness [18, 19, 20, 21], the simultaneous systematic barriers for women in engineering create intersectional challenges not readily captured in studies of only a single demographic category. As noted earlier, team experiences are often one significant site of barriers and exclusions. As a result, in this study we ask two questions:

1. What aspects of their team experiences emerged as salient for participants?

2. How did participants' team experience intersect with their perceptions of themselves as engineers?

Sensitizing Concept: Intergroup Contact Theory

To inform this study, we look to an established social psychology theoretical framework, intergroup contact theory (ICT). ICT focuses on the face-to-face interaction between members of different groups - in this case, groups comprised of different genders and races. ICT posits that intentional and supportive contact between groups reduces bias and prejudice and identifies six conditions that are necessary for these outcomes: (1) equal status within the contact situation, (2) intergroup cooperation, (3) common goals, and (4) support from authority, (5) personal interaction and (6) friendship opportunity [22, 23]. Table 3 (in the appendix) provides detailed definitions of these six conditions. Intergroup contact theory, though not the source of a priori codes for this analysis, served as a sensitizing concept and informed our interpretation and discussion of the results.

Methodology

To explore the experiences of African American females on engineering teams, we analyzed a subset of data collected through a phenomenological study of the experiences of African American students on multiracial student teams at a PWI. The original study followed Seidman [24], using a three-interview sequence to capture participants' experiences as they participated in a team project in an engineering course. To develop an initial analysis of the data set, in this study we focus on the third of the three interviews (described subsequently), which occurred after the completion of the team project and asked participants to reflect on their experiences. We selected the third interview for this initial analysis because these interviews effectively illuminate the ways in which participants made meaning of their experiences and how their experiences intersected with their engineering self-perception. The study was approved by the university's Institutional Review Board (IRB# 13-901).

Methods

Author Positionality

Because of the ways in which the systems of power and oppression interact with intersectional identities, there is variable impact on each of the writers of this study. We have supplied positionality statements for each member of the research team to add context to this work and to be transparent in how we approach these concepts [25].

Author 1: I am a queer, White woman raised by upper middle-class parents in a suburb of a mid-sized Southeastern city. I attended a mid-size public high school that was mildly diverse in terms of race and socio-economic status. I attended the same large, research-focused, public land-grant university as my parents and sister to study biomedical engineering. Due to the focus of this project on African American females in engineering, my identities are important to note, since I am the primary analyst of this data. Because my role in this is as an analyst of previously collected data, I may have placed implicit biases in the way I interpreted the written transcripts. I was not present during data collection to hear the participants' voices or see their facial expressions, and therefore I only draw conclusions from their transcribed words. I cannot relate to many of these experiences first hand because of my identity as a White woman.

While I recognize that my identity as an individual in a same-sex relationship contributes to a marginalizing experience, I am also aware of the inherent contrast between the challenges associated with my sexual orientation and systemic manifestations of racial discrimination in both educational settings and society as a whole. Being a member of the LGBTQ+ community has given me insight into the complex challenges of negotiating social norms and expectations and fostering empathy and understanding. However, I realize the distinct and deeply ingrained challenges for people who face racial oppression. It is critical to approach the study of various identities with respect, acknowledging the unique obstacles that each group encounters while working together to promote diversity and foster inclusivity.

I have investigated teaming experiences in several capacities as well as experiences of women in STEM. However, my own undergraduate teaming experiences have been limited in terms of diversity in identity and discipline.

Author 2: I am a heterosexual, White woman raised by two working-class parents in a double-income household. Both parents are first-generation college graduates from the Midwest, and they raised me and my two siblings in Orange County, California. I graduated from a private, teaching-focused university in Texas with bachelor's and master's degrees in civil engineering with an emphasis on structural engineering. I also worked for three years as a structural engineer before going back to school and pursuing engineering education. My education and career in engineering took place in predominantly White, male settings. Because of the privilege I experience as a White person and the sheltering of experiences that my privilege offers, I have undergone a massive amount of learning to identify systems of oppression embedded in the culture that may limit others in the profession. My goal with my research is to explore norms in engineering to understand and identify systems of oppression embedded in the culture that may limit marginalized communities in the profession.

Author 3: The third author is an experienced engineering education researcher who identifies as cis, heterosexual, and White. She grew up in a working-class family as a second-generation American whose grandparents immigrated from Europe in the early 1900s. Her research has consistently addressed both diversity and inclusion and design teams in engineering education.

Author 4: I am a Black, female, same-sex loving engineering professor with strong beliefs around spirituality. I am a first-generation PhD in my family and was raised in a racially and economically segregated large city in the Midwest. My research agenda is to broaden participation in engineering. My previous research investigated the experiences of multiple marginalized groups including women of color and members of the LGBTQ spectrum. I typically take an intersectional approach to identity in research and I am passionate about giving voice to those often overlooked in the business of educating engineers in the U.S.

Participant Selection and Recruitment

This data was collected as part of a larger exploratory phenomenologically-informed study [26] of self-identified African American students in the College of Engineering at a large, research-intensive institution. Recruitment included both in-person solicitation at meetings of relevant student organizations (e.g., NSBE chapter) and events sponsored by the engineering college's academic support center. In person recruiting was followed by a screening survey; participants were able to review the informed consent and made aware of their right to remain anonymous and withdraw from the study at any time. All recruitment and screen materials used the term "African American" to designate race; the gender choices available were listed as "male" and "female" (a significant limitation of the study that reflects the time of the data collection). Each participant was compensated $50 for completion of all three interviews; the amount was prorated for each interview completed.

Participants

For this study, we included nine participants who self-identified as "African American" and "female" (note that at the time of data collection, there were no non-binary options on the screening survey). Each participant was in an undergraduate engineering program and was, at the time, enrolled in a course with a team project. The project experiences for these participants ranged from a few weeks to a full semester or year. Each participant's pseudonym and academic major is listed in Table 1. This study is focused on females only and not inclusive of all genders because it has been shown that women of color in STEM have differing preferences in regard to team engagement than men [27] as well as perceptions of peer interaction [28]. This narrowed analysis allowed for more in-depth descriptions of the nuances of the teaming experiences of African American females in undergraduate engineering.

Table 1: Participant Information

Pseudonym	Major
Charlotte	Undeclared
Ciara	Computer science
Deliah	Biosystems engineering
Dominique	Electrical & computer engineering
Evangeline	Industrial & systems engineering
Florence	Materials science
Karina	Engineering science & mechanics
Majorie	Construction engineering & management
Rowan	Mining & materials engineering

Data Collection

Interviews were conducted during a single Spring semester in the first half of the 2010s. Interviews were conducted in the researcher's office, and they were audio recorded and then transcribed verbatim by the interviewer and two trained transcribers. Each participant was interviewed three times, with the interviews performed at least three weeks apart. The first interview focused on the participants' backgrounds and included previous team experience and overall relevant life experiences. The second interview gathered information about the current team project in which the participants were participating. The third and final interview prompted the participants to reflect on their experiences during the course of the project. This method was informed by Seidman [24] and the semi-structured nature allowed for flexibility in how the interview was conducted based on the participants' responses.

Several of the most relevant questions from the third interview are included for context in participant responses.

- How did your team interactions make you feel?
- What type of interactions made you comfortable working with your team members?
- What did your interactions with your faculty mentor or instructor for the course of the project mean to you?
- How would you describe yourself as an engineer?
- How do you feel about being the only African American on your team?

Since the original phenomenological study from which this data is drawn focused on African American students of two genders, the protocol did not include questions relating to gender. Instead, gender emerged in participants' responses to the interview questions. The full protocol is available in [26].

Data Analysis

To scope our analysis for this exploratory conference paper, as noted, we focus on the third interview because it provides the fullest reflection of the participants on both their team experience and their perceptions of themselves as engineers. This set of interviews thus provides a meaningful basis for identifying salient aspects of participants' team experiences and perceptions of themselves as engineers. Data analysis followed Miles, Huberman, and Saldaña [29]. The first author began by reading through all nine third-interview transcripts to gain a general understanding of each participant's experiences. We then used a structural coding pass to identify similar experiences across the participants and form initial codes. We used MS Word to create a table of all salient excerpts of participant responses in the interview transcript and associated codes, then reviewed the transcripts again and performed pattern coding to identify any additional excerpts. Individual codes were then combined into larger categories as appropriate. The final categories and codes, along with their definitions, are listed in Table 2. Note that in these codes, we treated both race and gender as aspects of individuals' identity, consistent with the Abes and Jones model of multiple dimensions of identity (MMDI) [30].

Table 2: Operationalized Code Definitions

Code	Operationalization
Importance of good communication	Statements that emphasize success when the team communicated well or mention that poor communication causes team conflicts
Importance of collaboration	Statements that relay the success of a team from working together toward a common goal
Importance of friendly/informal interactions	Statements from participants about becoming more comfortable with their team members when they had friendly conversations
Improper skill sharing/delegation of tasks	Statements from participants about a time when they felt they could not contribute to the project, maybe from lack of knowledge or other group members taking over
Not having necessary background knowledge	Statements from participants about missing certain knowledge relative to their project. Maybe the others learned it outside of class or before coming to college
Negative feelings about the future	Statements about the participant being discouraged about the future
Being the only African American	Statement from a participant about being the only or one of a few people of color
Experiences with men vs women	Statements in which the participant brings up gender identities of their team members to contextualize their experiences
Experiences related to race	Statements in which the participant brings up their own racial identity to contextualize their experiences. When their racial identity was salient to their experience
Feelings as an engineer	Statements where the participant describes how they view themselves as an engineer

Research Quality

Details on research quality relating to the original study are available in [26]. For this analysis, the first author maintained a detailed audit trail to capture the thoughts and feelings during analysis and identify possible biases that may have affected interpretation of the data. This audit trail was updated after each coding session and increased the transparency of the coding process. The final categories, definitions, and coded excerpts were then reviewed by the second author. Peer review and debriefing during the development of this manuscript served as a final quality check.

Another read through of each interview transcript was performed with these themes in mind. Additional excerpts from the text were added when appropriate. A preliminary codebook was developed that further defined the categories. Each theme was given a brief definition, a full definition, a description of when to use and when not to use the code, and an average of three examples from the transcripts that best exemplified the code [31].

Limitations

Only nine participants' experiences were examined to study teaming in engineering learning environments. As is the nature of qualitative research, the project scope cannot expand to represent the experiences of all undergraduate African American females in engineering. This paper aims to reveal the systemic issues reflected through the unique experiences of these nine participants from a singular PWI. The purpose of qualitative research is not generalizability, but focusing on the experiences of specific individuals.

In addition to methodological limitations, the primary analyst had no role in developing the data collection protocol. There were also time and resource limitations on the secondary analysis - no qualitative data software was used and most of the analysis was performed within two months. Because this study was a secondary analysis, there was no opportunity for member-checking with the participants. As a result, the coders were responsible for the analysis of the data and representing the participants accurately without their validation.

Results

The following sections describe each of the categories in more detail, using participant quotations to illustrate each. The codes were grouped into three overarching concepts: Importance of good communication, Imbalance of skill sharing/delegation of tasks, and Engineering self-perception. Note that all participant pseudonyms were changed for the secondary analysis.

Importance of good communication

One finding that was evident in almost all interviews was the importance of good communication among team members. For some participants, like Deliah, it emerged as an aspect of the team experience that facilitated their success:

> You're not going to get anywhere if the whole team's not on the same page... Because if you're not communicating and you're not coming to decisions with each other, then it's just all going to fall apart eventually, in my opinion. (Deliah)

Evangeline confirms this sentiment when she says "Communication is essential to having productive teamwork... true communication, where someone is talking, someone is listening and all that." Together, Deliah's and Evangeline's comments showcase the necessity for student teams to have good communication to be able to work toward a common goal. Ciara connected her positive teaming experience to the strong communication her group had. She expresses:

> We had a good team experience because we were all like trying to figure it out together and so we were all like forced to talk to each other. (Ciara)

In other cases, participants cited the lack of good communication as a primary cause of team conflict. For example, Charlotte thinks that most of her group's issues stemmed from the poor communication they had:

> There just was not enough communication. I'm pretty… like I'm 90% sure that that's the problem, the overall problem, with the group. (Charlotte)

Several participants also noted the ways in which informal conversations separate from the project work helped them feel more comfortable on the team. For example, Dominique noted that for a good team experience, the members must be able to be comfortable with talking to each other and "joking around."

> While we were working, we had little side conversations and just talked about nothing while we were working. It was just a comfortable atmosphere. Everyone was okay with each other, no one really had any problems with anyone else, so the interaction within our group was, I thought, normal for like what you'd want in a good team. Just being able to talk to your group members and just joking around with them while working. (Dominique)

In supplement to "good communication," excerpts like this one about informal communication focused on the ways team members could become more comfortable with each other apart from the central project work.

Imbalanced skill sharing/delegation of tasks

Workload and task delegation most often emerged as a source of frustration or negative team experience as multiple participants felt that they were not contributing enough to project tasks. They perceived an inadequate or inappropriate division of work among group members. Dominique, for instance, talked about wanting to do her "share" of the work.

> It was just kind of that feeling, like 'Does everyone think I'm doing enough work?' I mean, I'm trying to do more work and all that stuff, and it's that mutual feeling of like 'Don't be the slacker in the group, don't be the slacker in the group!' (Dominique)

Dominique felt lacking in her contribution to the group because she did not have familiarity with the specific coding language being used. She references differences in knowledge coming to the undergraduate engineering program:

> The kids that had the experience with Java in our group, they learned it in high school. And I guess their high schools had like better clubs or just classes that taught them how to work this program so they could be kind of ahead of the curve. (Dominique)

The unequal division of work among Dominique's group arose from certain members having specialized knowledge that allowed them to do more of the work. This introduces the idea of unequal access to early STEM exposure and learning. Without incorporating data from the first two interviews, it is impossible to say what level of access the participants had to STEM in middle and high school. However, it is a larger issue that has been demonstrated [32].

In some cases, as with Charlotte's situation, this concern about task delegation was linked to a perceived lack of knowledge or skill. Charlotte explained that she was excited to help with certain aspects of the project, but perceived that other team members had more knowledge and did not accept her input. When asked about this issue, she expressed frustration:

> I feel like I haven't been a part of the project because I haven't been tasked with anything, I haven't been able to... I feel like I haven't been able to contribute [Okay]. And I really wanted to help with the coding part, but I didn't know what I was doing, I didn't know how to help. (Charlotte)

> It made me feel annoyed because I did want to help, but it's like I wasn't given a chance. And it made me feel lazy because I didn't get to contribute anything to this project. (Charlotte)

After discussing how she was not tasked with anything to do on her group's project, Charlotte reflects on what could have made the situation better. When asked what specific types of interaction would be important for her team, she responded "I think the delegation is the number one, like most important thing."

Engineering self-perception

Finally, participants' team experiences intersected with and influenced how they perceived themselves as engineers. Karina, for example, realized that she enjoys the hands-on aspect of engineering. She described her overall team experience as positive and saw it as an opportunity to apply more engineering principles in practice more directly than in her coursework. Interestingly, this opportunity for hands-on project work not only helped Karina identify unknown strengths, but also made her rethink her engineering subdiscipline.

> I have figured out through this process that I am a far more hands-on individual than I gave myself credit for. I feel like I would have done a lot better in mechanical. (Karina)

Similarly, Florence also came to identify important strengths through her experience on the team. Noting that she didn't see herself as the most technically knowledgeable member of the team, she admitted she "...might underestimate [herself] more than others do." At the same time, she identified her own strengths in process and commitment:

> I'll just describe myself as probably seem – like I was talking about the whole time – just efficient, really team-oriented. Um...like, I might not know how to solve the problem, but I'm willing to work with a team to help, like, come up with the best solution for the problem. (Florence)

For Dominique, the team experience went beyond individual skills and connected directly to her future in engineering. The project pushed her to work on a specific programming language that she'd had no previous experience with, and she noted,

> I'm definitely a better engineer now than I was at the beginning of the year...I know what things I need to work on for my specific kind of engineering...I've definitely developed that creative, critical-thinking side of myself. (Dominique)

That is, beyond confirming specific skills, Dominique saw the ways in which the team project built her confidence; she sees herself as "a better engineer" now.

Cross-participant comparisons

The categories and codes described above highlight key features of both team dynamics and identity that emerged as salient for participants as they reflected on their team experience. Table 3 summarizes these features for all participants and includes their overall evaluation of the team experience as positive (+) or negative (-). Since there were no questions asking participants to give an overall response about whether their team experience was positive or negative, these are based on compiling information from throughout the interview. We discussed informal conversation as being an important subset of good communication in the results. The asset seemed significant enough to warrant a separate column in the table. We marked the column labeled "Self-perception as an engineer" based on whether the participant's view of themselves as an engineer (a question directly asked to them in the interviews) changed for the better (+), worse (-), or stayed the same (neutral) as a result of their teaming experiences. For two participants, answers that did not yield their self-perceptions are labeled "undisclosed."

Table 3: Participant Experiences

Pseudonym	Overall Team Experience (+ or -)	Experienced "good communication" (Y or N)	Experienced "Informal conversation" (Y or N)	Team had good task delegation (Y or N)	Discussed their race (R) and/or gender (G) as salient	Self-perception as an engineer
Charlotte	-	N	N	N	R,G	-
Ciara	+	Y	Y	Y	Neither	Undisclosed
Deliah	+	Y	Y	Y	Neither	+
Dominique	+	Y	Y	Y	Neither	+
Evangeline	-	N	N	N	Neither	-
Florence	+	Y	Y	Y	R,G	+
Karina	Neutral	Y	Y	Y	Neither	+
Mallory	Neutral	Y	Y	Y	R,G	+
Rowan	+	Y	N	Y	Neither	Undisclosed

Discussion

The results of this study align with past research on engineering student teams and support intergroup contact theory but also add unique experiences of African American females in engineering. All participants who had overall positive team experiences referenced having good communication, informal conversation, and good task delegation. The one exception comes from Rowan, whose group mostly emailed and therefore did not have the opportunity for informal interaction. The three assets that were common between participants with positive experiences (good communication, informal conversation, and good task delegation) are consistent with three of the six conditions of ICT. Examining the other conditions was outside the scope of this paper. Conversely, participants with negative teaming experiences lacked the conditions considered important for positive contact among members of different identity groups.

The results of this secondary qualitative data analysis suggest how differences in skills among team members can create an unequal division of work. Furthermore, technical skills and communication play a role in this phenomenon by exacerbating the inequality between team members and not providing an avenue to discuss it. Teams with strong communication can more easily establish everyone's strengths and weaknesses to maximize individual contribution. Teams with poor communication, however, could only find value in technical skills, and therefore those with less developed technical skills felt unable to contribute to the team's efforts. For example, Charlotte and Dominique both felt unable to contribute much to the project because they did not have the same coding experience as some other team members.

Lastly, this secondary data analysis revealed some of the overarching effects of undergraduate student team experiences for African American females in engineering. These experiences revealed the strengths, weaknesses, lessons, and passions of the participants. The participants recognized the assets discussed in this paper as valuable in constructing a teaming experience that was conducive to achieving the common goals of the team. This secondary data analysis further shows the importance of facilitating positive team interactions in undergraduate engineering. To maximize positive outcomes for students, especially minority students, undergraduate team dynamics should be carefully structured to support good communication, informal personal interaction, and equal division of labor.

Conclusion and Suggestions

It is clear from this study that multiracial student teams have a great impact on the academic experience of African American females. Although these are intended to be all positive outcomes, that is not always the case for underrepresented minorities in engineering, particularly African American females. Through this study, it was shown that strong communication and positive personal interaction played a major role in the team functioning. Unequal delegation of tasks and differences in technical knowledge made some participants feel unhelpful on the team. Several of the participants had negative experiences related to their race, gender, or both. They also shaped their perceptions of the future and their feelings of themselves as engineers based on their teaming experience. While some had positive experiences and the participants learned new skills from themselves, others were discouraged or felt less like engineers. Based on these implications, greater effort must be made to create and facilitate multi-racial student teams. This facilitation

could take the form of intentional team formation, using workshops that promote diversity and inclusion, and help teams establish norms, roles, and goals. Additionally, students should be taught about the importance of teaming and be given examples of how working on teams shows up in industry and academia.

These overarching findings support the need for more opportunities for teaming experiences in undergraduate engineering programs. This would ideally increase the chances for all students to participate on a successful team that communicates well and fosters the development of engineering self-perception. In order to translate undergraduate experiences to the reality of working in industry or pursuing higher education, we suggest faculty implement intentional reflection during and after team projects. This will allow students to recognize strengths and weaknesses of their team and also positively reframe and contextualize their experiences to be better prepared for the future. This reflection can also help students learn more about their ideal working environments and preferred tasks within a certain engineering field.

Additionally, based on the experiences of multiple participants, it is beneficial to include individual performance assessments or evaluations to help the professor understand teams' dynamics. This would ultimately allow for intervention where necessary to foster better teammates and group attitudes. If a student does not share tasks, consider suggestions, include others, respect their teammates, etc. but is also not shown that those traits are inconsistent with a positive team, how will they improve?

Overall, this study was enlightening about the experiences of African American females on undergraduate engineering teams. Emergent results highlighted the importance of strong communication and effective division of work among team members. Additionally, analysis of the nine interview transcripts indicated that individuals' self-perception of themselves as an engineer is affected by teaming experiences, for better or for worse. Each of these findings highlights the importance of creating and facilitating positive teaming experiences in undergraduate engineering. The inclusion of and support of African American females is vital to the future of engineering as a field.

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Appendix

Table 4: Description of conditions for positive contact

Condition	Definition
Equal status	The members enter with and maintain equal status, or equivalent group power in the contact situation, throughout the contact situation
Intergroup Cooperation	Collaboration among groups for goal attainment through mutual cooperation among team members
Common goals	All group members support a shared task they deem worthwhile
Support of authorities	Applicable authority supports acceptance and position contact
Personal interaction	Voluntary interaction with all group members that results in cooperation
Friendship opportunity	Familiarity among all group members that builds over time increases inclusiveness