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Centering Equity and Inclusion in Engineering Collaboration and Writing

Jennifer C. Mallette
Boise State University

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Jennifer C Mallette (Associate Professor)

Jennifer Mallette is an associate professor of English at Boise State University, where she collaborates with engineering faculty to support student writers. Her research builds on those collaborations, examining best practices for integrating writing into engineering curriculum; she also explores women's experiences in engineering settings through the context of writing.

Centering Equity and Inclusion
in Engineering Collaboration and Writing

Abstract
This paper focuses on preliminary findings from a study that asked students and alumni to share their stories around teamwork and communication in engineering settings. In addition to student and alumni stories of team writing, engineering faculty were interviewed to learn more about how they approach collaborative and communication-based projects and how consider diversity, equity, and inclusion in their teaching. The goal was to connect the ways that instructors frame these collaborative projects and to surface how implicit biases may emerge and impact students. The findings reported here focus on what students and alumni participants shared about their positive and negative collaborative experiences, with an emphasis on the intersections between those experiences and their background/identities that may elicit bias from their peers. This paper concludes with recommendations for educators to work toward reconceiving their collaborative and communication-based assignments and to begin uncovering their own implicit biases.

Introduction
When asked if she wanted to be the project manager for her senior project team, an engineering student commented that she often found herself as a project manager, even if she didn't particularly want to be. She then shared a story about how she had been put on a team with two men who were notorious for not contributing. Her instructor later told her that she was put in that group to help manage these problematic students, which meant that her learning experiences were sacrificed to support those of the two men she was forced to collaborate with; ultimately, she had to do most of the work to ensure the project's success. Other women shared stories where they are forced to do more writing, whether it is being expected to take notes or feeling that they have to do more on the written product and less with the technical elements. Other students conveyed experiences with racism and other forms of bias—or observations of bias—within their teams. These stories, accumulated over several years of working with engineering students on improving their writing, led me to develop the study reported in this paper.

These stories underscored the inequities too often present in engineering teamwork, particularly around project management and communication. These inequities often mean women are burdened with the "menial tasks" of projects [1], thus undermining the message that communication is as essential as technical work. Despite the field's acknowledgments that communication and teamwork skills are essential, technical skills are still more highly valued, and women are often asked to take up more management and communication tasks and blocked from the technical [2]. In fact, studies have found that these divisions often lead women in particular to leave engineering: while making up 20% of all engineering graduates, "nearly 40% of women who earn engineering degrees either quit or never enter the profession" [1]. And while much of the focus of this study is on the relationships between writing/communication and retention for women, other backgrounds and identities influence how individuals are perceived and treated within collaborative settings [3].

This paper focuses on preliminary data from a study of student/alumni and faculty experiences with teamwork and collaborative writing. After a review of the literature on collaboration and team writing in engineering settings, this paper provides an overview of key elements that affect

student experiences in team projects. Of particular interest are the experiences of women and underrepresented students in engineering and what led to positive, productive teamwork and what elements led to negative interactions. The paper concludes with recommendations for faculty to center equity and inclusion in their team assignments in a way that supports the learning of all individuals.

Literature Review
This section summarizes some of the literature on collaborative writing in engineering education, including how engineering faculty approach collaborative writing, the impact on students and student learning, and how some minoritized groups (including women) may have disparate experiences in these teams.

Collaborative Writing in Engineering Education
Engineering students, educators, and practitioners are aware of the ways engineering practice requires strong collaboration skills beyond technical competencies [4]. In addition, the ability to work in teams and communicate is both embedded within and inseparable from the technical tasks that define engineering workplaces [5]. ABET requires programs to incorporate collaboration in order to meet outcomes and be accredited, and employers point to teamwork skills as necessary for success in the workplace. Engineering educators focus on developing these skills in various ways, from specific course assignments all the way up to developing a minor in engineering communication that aims to explicitly teach communication and collaboration [6]. In a review of engineering education scholarship, teamwork is addressed in several ways in the classroom, including cooperative learning and team-based learning that focus on community-based projects [7], industry partnerships [8], and interdisciplinary efforts [9], often taking place in capstone experiences [10]. These projects often offer "authentic training experiences that emulate industry teams, which are composed of members selected for the diverse and complementary expertise they bring to a complex, real-life problem" that engineering educators value and lead to stronger teams in academic settings [8].

These efforts can be roughly divided into two main tracks: 1.) using teamwork assignments as a way to increase opportunities for peer-to-peer learning and active learning [e.g. 11-12] and 2.) using teamwork assignments to develop collaboration skills [e.g. 7-10]. The former focuses on individual learning through teamwork, while the latter focuses on projects that allow students and faculty to leverage the potential of teams to solve problems and support projects that often have tangible outputs beyond the classroom. In some cases, in-class writing and work can be used alongside collaborative learning, where the goal is using writing and peer engagement to learn course concepts more effectively [11, 12]. In other cases, teamwork assignments may not focus on writing specifically but use writing to communicate design solutions or data analysis. Typically, these projects may culminate in a report, a presentation, or some tangible product that involves writing (e.g. a final team report communicating results to a project sponsor). These projects may also be used to assess ABET outcomes for communication and teamwork, indicating their use for assessing students' abilities to apply technical knowledge to solve problems collaboratively while also communicating those solutions effectively.

Based on a 2013 review of engineering education scholarship, when faculty assigned team projects, they primarily targeted outcomes based in teamwork, design, and communication, with

some focus on innovation, lifelong learning, ethics, and motivation [8]. In a breakdown of the teamwork outcome, researchers found a focus on global/cultural competence (for both team members and clients), project management, and interdisciplinary teamwork, as well as some focus on societal concerns, distributed teamwork, leadership, and time management [8]. In engineering contexts, instructors sought to minimize or manage "social loafing" or slackers—students who do not contribute to projects fully—as well as conflict management. These instructors aimed to prepare students for the teamwork and communication expected of them in industry. Essentially, instructors' "efforts are frequently directed at ensuring that students manage their time, work together well, and each contribute their fair share of effort" [8].

Overall, this brief overview of the research demonstrates a strong concern with supporting students as they develop the professional skills that they need to be successful engineers. With an emphasis on authentic, real-world problems and community-based or industry-based engagement, engineering educators strive to create effective teamwork environments. These educators know that collaboration and communication are crucial to an engineer's success, and employers increasingly expect graduates able to work effectively in team environments and communicate well in both oral and written forms.

Models of Collaborative Writing
Depending on the approach assigned by faculty or selected by students, as well as the assignment outcomes and end products, collaborative writing can take on three main forms: synchronous drafting, divided, or layered [13]. In addition, students may collaboratively revise by selecting the feedback method or the direct revision method [13]. These approaches for drafting and revising may be adapted at various phases in the project, allowing team members to select the approach that best suits the goals and stage of the written product.

Synchronous drafting requires the entire team to draft at the same time, potentially within a shared document. This model may look like the entire team working together face-to-face (in person or in a web meeting), with a point person (or two) adding to the document while others talk out what should be in the document [13]. This approach is time-intensive, but it can work effectively for the planning phase or parts that need everyone to provide input simultaneously.

Alternately, students may opt for the divided approach, where everyone takes a specific section of a document and works independently to complete their assigned section [13]. Faculty and students may be most familiar with this approach to collaborative writing and also know the problems this method may create. This method requires less team coordination, but it can result in written products with uneven writing style and possibly overlap and redundancy among the paper's sections, particularly if the team does not revise the document for content and cohesion.

The final approach to drafting is the layered approach. Wolfe describes the layered approach as "Each person on the team is assigned one or more specific roles. Each person works on the document in turn, adding his or her own expertise to the product. The document slowly accumulates in layers as each team member revises and improves upon what already exists" [13]. This approach has advantages in allowing everyone to contribute fully and often results in a stronger written product, but it does require more time and coordination.

After drafting, collaborators can approach revising the document in one of two ways (or combining their approaches). The feedback method (or single-author revision) requires teammates to add comments and use the editing function on their word processing software to make suggestions to the original writer, who then revises based on these suggestions [13]. In this approach, the original author "maintains primary responsibility for a section of text" [13]. The other method is direct revision, where changes are made to the document directly [13]. This method removes control from an individual author and may be used at the end of the document if the team assigns this task to one or two writers/editors. The benefits of direct revision is that it can be more efficient and work well for the end of the writing process to ensure the document has a consistent voice throughout, but it can create conflict if an individual writer feels that their contributions are erased or ignored. It also requires the team to complete the full text with sufficient time to dedicate to revision, which can be a challenge in contexts where students are often drafting up until the submission deadline.

Supporting Impactful Team Projects
Given the increase in virtual/remote work, one site for intervention is building trust and cohesion when team members are not in the same space. One study examines the impact of trust on virtual teams, finding that teams whose members already know and trust each other are likely to be more effective [14]. They also found that teams should spend time at the start of a project purposefully building trust among team members with no previous relationships [14]. Similarly, another study examines the strategies that contribute to a multilingual team's success in a virtual environment, highlighting the advantages of diverse teams on solving problems and generating innovative solutions [15]. Other research specifically demonstrates the impact of team projects on student retention [16]. When successful, these collaborative projects can help underrepresented individuals create a sense of belonging in engineering spaces, a key factor for persistence [16].

Other studies have examined strategies to help individuals build skills that allow them to collaborate successfully. For example, Campbell and Lam [17] study the impact of providing leaders with direct feedback based on support, attention, and praise. This study offers interventions to support leadership development and potentially improve teamwork experiences, but they do not address the ways gender bias or other biases affected student rating and interactions within teams, nor do they share the demographics of the leaders in comparison with the demographics of the class.

Other interventions take aim at disrupting the dynamics that lead to implicit or explicit bias. Explicit instruction on leadership skills and communication that addresses bias can serve to support all students in the class and allow them to cultivate communication and collaboration skills that will improve performance [18]. Fowler and Su's study proposes interventions to support mastery orientations to encourage students to avoid taking on the tasks they feel most comfortable with. They also propose instructors intervene to disrupt power dynamics, help make individual student learning goals visible to the whole team, and assign students intentionally to roles that they may not choose for themselves and support skill development [19]. As noted in a previous study by this author, instructors can carefully structure teamwork to point out places for bias—such as notetaking, project management roles, and the tendency to divert women into

written elements—and require these tasks to rotate among all team members and for instructors to evaluate contributions accordingly [20, 21].

Other studies have focused on supporting virtual teams, which has been a focus as the use of distributed teams has increased alongside technological innovations [e.g. 22]. The need for effective management of distributed/virtual student teams, however, has increased with the shift to remote learning in 2020 and continued use of virtual communication tools. Methods and approaches for effective virtual and/or distributed teamwork have been taken up in a number of studies with clear implications for engineering education [e.g. 14-15, 23]

While some faculty may assume students will work together effectively without explicit structures, others recognize the need to help students develop that skillset. For faculty who hope to create more effective team writing experiences, books such as Moses and Tham's *Collaborative Writing Playbook* [24], meant for instructors, or Wolfe's *Team Writing* [13], a textbook for students, offer approaches to design effective projects. These texts provide guidelines for structuring team projects (such as having teams complete a charter and schedule as well as approaches to assigning roles), mechanisms for improving communication among teams (such as using meeting minutes), and ways for instructors to provide feedback to teams and teams to provide feedback to each other [13, 24]. Wolfe's textbook includes a site where instructors can access videos for class discussion and templates for team documents, such as charters and task schedules [25]. Other materials available from Carnegie Mellon's Global Communication Center include support for overcoming bias, managing team projects, and other materials to support writing collaboratively [26]. These materials and textbooks recognize the need to deliberately structure team writing and collaboration to support student experiences and cultivate the development of collaborative skills, particularly with a focus on communicating as a team.

Despite all of these studies on best practices for teamwork, other work has found that faculty often ignore recommendations for supporting student teams. One study found that faculty participants "did not have rationales for how they form teams, do not actively manage team roles, do not have effective mechanisms for identifying problems among students on teams, and do not facilitate gender-inclusive teamwork practices" [21]. In addition, faculty expressed belief that the experience of bias on teams would give women invaluable experience (rather than viewing the experiences as a problem) and ignored recommendations for ensuring all students had equal access to the technical aspects of a project [21]. The outcome for many team projects is that students take on tasks they are already skilled in and students who could benefit from learning are diverted into other work, leading to "a 'rich get richer' model in which students develop expert knowledge in a subset of skills necessary to complete their [project-based learning] work, while selecting out of tasks they need to complete. This is directly counter to the instructors' preference that students develop mastery across all of a course's learning objectives" [19]. These findings point to the need for better interventions that allow faculty to plan and support inclusive and equitable teamwork in engineering.

Bias and Negative Experiences
Despite efforts to mitigate bias and create learning experiences that support all students, underrepresented engineering participants may still have negative experiences on teams as a

result of background factors such as race and gender. These experiences echo the problematic climate in engineering workplaces that continues to marginalize women and other underrepresented participants and contributes to underrepresented and minoritized engineers never entering the field or leaving the field [1, 2]. Furthermore, teamwork is often implemented in engineering courses without attending to the well-documented gender biases that affect women's experiences in these settings and in ways that may exacerbate these biases [21]. For example, one study demonstrated that the lack of explicit negotiation and task management led women to take on more of the non-preferred work in a team project [19]

More troublingly, one study found that engineering faculty either were unaware of issues related to bias on student teams, or they did not have the skills to intervene successfully [21]. Most problematic of all was the finding that professors did not think gender bias was an issue that required intervention because those experiences better prepared women for the conditions they would face in workplace settings [21]. This study also documents the sorts of beliefs about women's skills and abilities that divert women into communication and project management tasks and away from technical work [21].

The association of women with strong communication skills can be leveraged by women in engineering to support their success. But it comes with costs when women are diverted into project management and communication work and excluded from the technical elements that come with higher professional rewards [1, 2, 19, 21, 27-31]. As one study found, choices in team task allocation can be partly explained by implicit gender bias: students made assumptions about individual team members' abilities based on gender, which led to inequities in task allocation [30]. Another showed that while women were more likely to rate their presentation performance more highly when more women were in the group, team composition affected how men and women took on roles and believed in their abilities to perform tasks [31]. In this study, women were more likely to have less speaking time and present less technical material than the men on their team, who had more speaking time and presented more technical material. As the authors conclude,

> by virtue of being underrepresented and the target of negative stereotypes in engineering, women are more likely to adopt passive, supporting roles, and men to adopt active roles in which they have the opportunity to 'learn by teaching others". By disproportionally missing the opportunity to explain the technical aspects of the project to an audience, women students may be at a disadvantage both in terms of their technical understanding and their perceptions of self-efficacy in engineering. [31]

These associations feed into the continued ways that women and racially minoritized students are more likely to underestimate their math and science skills when compared to their white, male counterparts, indicating lower self-efficacy in those areas [3]. As Fowler and Su argue, "team-based learning can actually endanger students' self-confidence and perception of themselves as engineers and computer scientists" [19]. Meanwhile, women are more likely to rate professional skills (including communication) as more important than their male peers and are more likely to use communication differently to accomplish their goals [3]. Taken together, these studies confirm the ways women continue to be associated with stronger professional skills and thus purposefully or unconsciously diverted into the communication and project management work

that may be undervalued and unrecognized and thus lead to their decisions to leave the engineering field.

In team projects, these dynamics factor into the more negative experiences that women have in teams, experiences that can impact retention of women in engineering. For instance, women in one study shared feeling "that they must work harder than their male peers to get teams to acknowledge the work they've done" [18]. This study also found that approaches to communication that are the result of gender socialization (e.g. women's tendencies to "soften" criticism by framing it with *I think* or *I believe*) led to women's contributions being ignored or dismissed, even when valid [18]. In these gendered spaces, women also may experience bias in the form of their male peers dismissing their knowledge and skills or underestimating their abilities [32]. The diverting of women's work into less visible contributions may also factor into the lower rates of publication and grant funding women experience in STEM fields [33].

In a past study that laid the groundwork for the research reported here, two women shared their experiences with teamwork in their undergraduate classes. While they had mainly positive experiences, for one participant, her gender played a role in the negative experiences she identified [20]. Both women reported that they believed women were better writers than the men, a belief that reinforces conventions about women as better engineering communicators [27-29, 34-36]. This belief also feeds into the stereotypes that can serve to perpetuate bias in engineering, including that the norm in engineering is that the typical (white, male) engineer possesses ineffective communication skills [37]. And while one participant noted that her writing skills were sure to serve her well in the future [20], overall, the trend is to associate women with project management, communication, and other "professional skills" that tend to receive lower status in engineering settings, all while diverting them away from the technical tasks that not only are perceived as higher status, but also pave the way for advancement.

In many ways, the focus of this paper is on gender-based discrimination on teams in part because of my past research in this area as well as the lack of racial diversity at my primary research site, though this study strives to address discrimination more broadly. In addition, gender is a key concern when it comes to retention, thus many of the studies focus on women's experiences specifically or separately from race or ethnicity, and few studies focus on the intersectional experiences of STEM participants [3]. As Ro and Loya's study points out, accounting for both race and gender bias in the self-efficacy of engineering students indicates clear directions for supporting students' professional skills development in the areas of communication, teamwork, and leadership [3]. One study in South Africa noted that while an overwhelming majority (92%) of students perceived social inclusion as important for teamwork, only 68% believed that teamwork experiences prepared them to practice inclusion "a moderate amount or a little" [38]. Furthermore, 37% of the students reported being marginalized or excluded on teams based on both racial and gender identities [38]. These findings point toward the need for more research that accounts for both gender and racial bias, and the intersections among various marginalized identities and their impact on students in teams.

Research Method
This IRB-approved study recruited current engineering students and recent alumni who have graduated from engineering programs at a four-year institution in the Mountain West to share

their experiences around teamwork and collaborative writing in the context of their engineering coursework or work experiences. In addition to recruiting students and alumni, engineering faculty were interviewed about how they incorporate teamwork into their courses and ways they consider equity and inclusion. This paper focuses primarily on the student and alumni data.

Participants were recruited from a range of disciplines in engineering. At this phase, the researcher recruited from students/alumni who previously took a course or who worked with the researcher on writing. These students and alumni were primarily in materials science and engineering and electrical and computer engineering programs. The participants either took an introductory engineering communication course with the researcher or worked with the researcher, who was embedded as a writing specialist in a junior and senior-level courses. Faculty participants had also generally worked with the researcher in some capacity. Because this study asks questions about experiences around bias and other potentially negative interactions, the participants who signed up needed to feel comfortable sharing these stories. At this stage in the research, no particular demographic was targeted, so the current data set includes men and women from a range of backgrounds, though predominantly white.

Those who agreed to participate were sent a short survey (see Appendix A) through Qualtrics. This survey collected initial demographic data, including a question about if the participant identified as a member of a minoritized group in engineering. This self-identification allowed them to determine if they identify as underrepresented rather than the researcher assuming that status. Other questions on the survey asked participants to gauge their comfort with both writing and teamwork and served as the foundation for the next phase of the project, the qualitative semi-structured interviews.

In the second stage, participants were interviewed about their experiences both as writers and collaborators (see Appendix B for interviews). The goal of this semi-structured interview was to understand how students/alumni experienced teamwork in their courses as well as in professional settings, if relevant. For faculty, the questions focused on ways they incorporated writing and teamwork into their courses, what considerations they make for equity and inclusion, and any experiences of bias they may have had as instructors or professionals. These interviews were focused on allowing the participants to tell the stories they wished to share. Interviews took place over Zoom or in-person and were recorded.

After the completion of the interviews, audio files were uploaded to AI transcription software for initial transcription and then edited for accuracy. Because the transcription software tends to remove verbal hesitations (such as ah or um), the researcher added those back in if it served a meaningful function in communicating thinking or hesitation. In this paper, some verbal hesitations were left out and quotations were lightly edited for clarity. Bracketed ellipses ([…]) were used to note where content was edited out. Overall, efforts were made to ensure the quotations reflected the speaking style of the individual, including leaving "like" or other potentially gendered language markers. Otherwise, the focus was on transcribing the participants' words clearly and accurately. Throughout the notetaking, transcription, and review process, the researcher made note of the emerging themes.

Limitations
This study is currently limited in that it has few participants with minoritized backgrounds other than gender identity. As the study continues, the researcher plans to recruit participants who can speak to the impact of other identities in engineering. The institutional context somewhat limits access, however. In addition, the study is currently small, so these stories represent only a few individuals' experiences, thus broader generalizations cannot be drawn.

The individuals presented here all have prior relationships with the researcher. While an advantage is the participants are more likely to respond candidly to questions because of a higher level of trust with the researcher, these past relationships mean that participants were likely higher achieving students who had positive interactions with the researcher. Thus, another limitation is that the participants opting in represent higher achieving students who cannot represent the full spectrum of writing and collaboration experiences.

Results
As of the writing of this paper, 10 students/alumni have opted to participate in the study (data collection is ongoing). Out of those 10 students, four identify as women while six identify as men. Four participants identified as an underrepresented minority, namely for gender and/or race as well as sexual orientation (notably, one woman opted to not identify as underrepresented). One participant was over 55, one in the 35-44 age range, two in the 24-34 age range, with the remainder (6) in the 18-24 age range, reflecting that most participants were traditionally aged current students or recent graduates. Table 1 below summarizes the participants, and the number corresponds with the survey data shown in Figure 1.

Table 1. Participant Demographics

Participant	Gender	Race	Age Range	Self-Identify as URM
1	Female	Other	25-34	Yes
2	Female	White, Asian	25-34	Yes
3	Male	White	35-44	No
4	Male	White	18-24	No
5	Male	White	18-24	No
6	Male	White	55 or older	Yes
7	Male	White	18-24	No
8	Male	White	18-24	No
9	Female	White	18-24	Yes
10	Female	White	18-24	No

An initial survey question asked participants to rate their skill level as writers and collaborators and to rate their enjoyment of collaborative writing. From the student and alumni participant pool, all participants rated themselves at a 4 or 5 for their confidence in their writing skills, indicating that the participants who self-selected into the study were fairly confident in their ability to write (see Figure 1; number corresponds with participant table above).

As shown in Figure 1 below, in terms of confidence in their ability to collaborate, participants rated themselves from 3 to 5, either the same or lower than their confidence in writing skills,

with the exception of one participant. When asked how much participants enjoyed collaborative writing projects, responses ranged from 2 to 5, either the same as or lower than their confidence in their collaboration ability, with the exception of one participant to rated their skills slightly lower than their enjoyment. Overall, participants were confident in their ability to write, fairly confident in their ability to collaborate, but some participants enjoyed collaborative writing less.
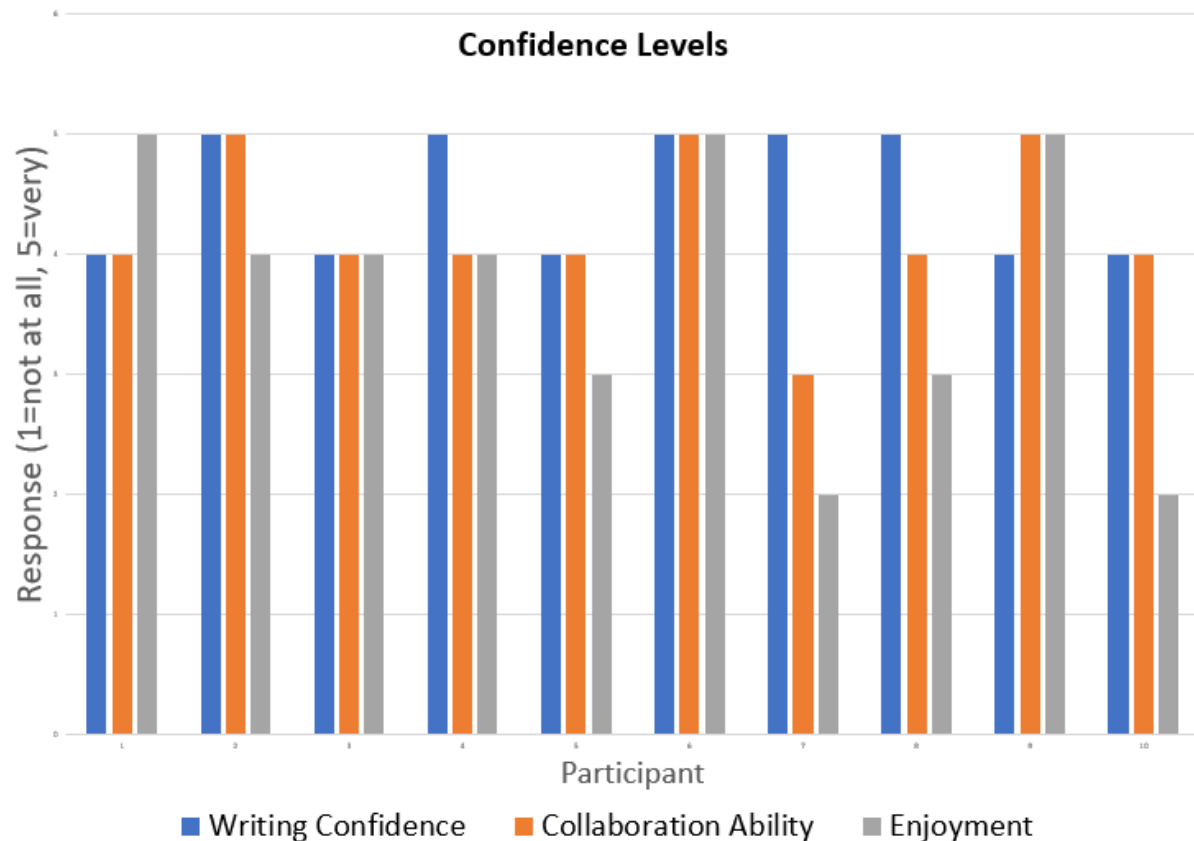
Figure 1 Student/Alumni Confidence Levels in Writing, Collaboration, and Enjoyment of Collaborative Writing

Based on this survey, no correlation exists between gender identity (or underrepresented status) and enjoyment of collaborative writing. The results also seem connected to the most recent collaborative experiences that participants had prior to taking the survey. For instance, Participant 1 rated herself somewhat lower on writing confidence and collaboration ability—but higher on her enjoyment of collaborative writing. Similarly, Participant 9 also rated her enjoyment higher. In the interviews, these two participants shared recent experiences with collaboration and writing that were positive and underscored how beneficial good collaboration could be—they both shared that they worked with individuals who were supportive of them and their work who they felt they could learn from, and that their teams created products that were stronger in the end. Conversely, Participant 10 rated her enjoyment as lower because she currently was in the midst of less positive and productive collaboration experiences: she was being tasked with project management work that she did not voluntary take on. These experiences show that context and the nature of recent collaboration may affect how respondents rated themselves in these areas.

Why teamwork matters in engineering
Every participant noted that engineering programs incorporate teamwork into team projects because it aligns with the expectations of the engineering workplace. One participant highlighted the advantages of students having opportunities to develop their voice or learn to express themselves, particularly for women, as well as for those who may not be comfortable communicating their ideas in team settings:

> So I think it's just really important, especially you can kind of get ideas from your classmates, and you can also share your own ideas. And you really want to find your voice. Especially as a woman, I think it's really important to find that voice in the engineering world. So—I think anyone who's not comfortable sharing their voice could benefit by, by learning to do that in a group. […]I think it's important when doing group work that people are finding their voice, and they're not allowed to just kind of sit back and accept everything.

The participants who were alumni were stronger in their belief of the importance of teamwork assignments in undergraduate engineering programs because they found their work was heavily collaborative. They understood that their ability to collaborate in the workplace led to effective solutions and successful task completion—collaboration across disciplines, languages, cultures, and skill levels is the reality of the technical workplace.

Factors influencing success
Three factors were critical to successful projects and positive team experiences: 1.) equally divided workload, 2.) shared goals and expectations, and 3.) clearly defined roles and tasks. These three elements helped teams build trust and community and communicate clearly with one another. Participants pointed to team experiences as positive when all the members were as committed as they were to the project. One participant pointed out that equal contribution did not mean never missing a task: it was more about clear and open communication. If someone had to miss a meeting or needed help finishing a task, as long as they communicated clearly with their teammates, they were still viewed as contributing actively. By contrast, not communicating ahead of a deadline or giving a vague excuse such as being busy was not seen as acceptable and led participants to feel that the teammate was not contributing equally.

This equally divided workload was also built on shared goals and expectations. Participants were more likely to talk about positive experiences as ones where everyone was committed to a shared goal and willing to meet the same standards. These teams recognized that everyone wanted to be successful and were willing to put in the effort to reach that goal. These shared goals and expectations were then met through clearly defined tasks and roles. While the roles were not always explicitly named—e.g. someone was given a title—participants enjoyed projects were all team members determined the ways they wished to contribute and then do so. These roles allowed each team member to have autonomy in completing tasks that aligned most with her goals and interests and also facilitated the success of the final written product.

Features of negative experiences
One of the key factors in negative experiences was the presence of slackers or social loafers— essentially teammates who take advantage of someone's commitment to completing a project

and do not complete their fair share of the work. On the survey, nine out of ten participants noted slackers as one of the top three drawbacks to collaboration; four participants also indicated that doing more than their fair share was another primary drawback.

While slackers may not contribute fully to a project for a variety of reasons, one participant called out not contributing as "faking incompetence," where someone who is clearly capable feigns a lack of ability to avoid contributing:

> And the really frustrating part is it's fake incompetence. Like I had worked with two of them before […] and it's fake competence. So like, it's not even like they actually couldn't do it. I think it was that […] they knew that I was more committed to it than they were. So they could kind of take advantage of that. And I could, and I would make sure that the project got done.

Taken together, these interactions led teams to be less productive. Those who wanted to create a successful project also felt that they had to carry the team in ways that lead to negative experiences. For some participants, the presence of slackers may also be connected to gender dynamics and other forms of bias, particularly for the women who worked with only with men.

Differing ideas of quality and a lack of shared goals contributed to negative experiences for many of the participants. On the survey, five out of ten pointed out that differing ideas about high quality was one of the top three drawbacks of collaboration, with two also noting lack of shared goals; one participant also included "differing ideas and approaches" in the other space. Relatedly, three participants noted that writing completed at the last minute also was a drawback, which may also indicate differing opinions about the value of writing to a project, commitment to high quality writing, and willingness to work with others to communicate effectively.

A final factor is feeling forced into taking on the management of a project; this factor relates to unequal work distribution. Four of the ten survey respondents noted that being forced into specific roles or into managing the project led to more negative experiences. One reason is participants seemed to value autonomy, and they enjoyed experiences where they were able to contribute in the ways best suited to their goals, skills, and interests. In addition, these experiences reveal some of the ways gender dynamics play out in team projects. One woman participant shared the experience of being assigned the role of project manager on a team with two men, despite her desire not to manage the project. She felt that the gender dynamics influenced how the team failed to work together cohesively.

Discussion and Analysis
Overall, participants understood why they team projects were required in their undergraduate courses. Those participants who were alumni were especially attuned to the need to develop collaboration skills because as one participant said, "in the actual real engineering world—and honestly, I even saw this in retail—is you usually work […] collaboratively, with a smaller team." Participants were keenly aware that collaboration is part of the nature of the engineering workplace, even if they had not yet held an internship or position in engineering. Furthermore, participants recognized the benefits of successful collaboration, noting the ways that they could get at better solutions with a team, generate better ideas, and do more while working less

individually to create a better end-product. These benefits, however, were only observed on team projects that were successful. Successful projects featured teams with a high level of trust, clear communication, and cohesion.

Impact of Past Experiences
Based on the combination of survey data with interview data, past experience factors into participants' attitudes toward collaboration. Some participants rated themselves as skilled or highly skilled in writing and/or collaboration while also rating their enjoyment as lower. While not a large enough sample to draw statistically significant conclusions, a somewhat inverse relationship between writing skill and enjoyment of collaboration emerges in the dataset. For those participants, they tended to rate themselves as less likely to enjoy collaboration because of past experiences: these individuals struggled in the past to navigate teamwork environments where the work was equitably divided and/or was produced at the high quality they held themselves to. In these cases, participants (regardless of identity factors) rated their enjoyment lower.

Women's Experiences on All-Women Teams
A revealing finding emerges, however, from the women who had teamwork experiences on all-women teams. Out of the four participants identifying as women, three specifically called out their experiences in self-selected, all-women teams. On the whole, the three women rated these experiences as among the most positive, if not the most positive, of their education. While gender segregation should never be the norm for forming teams in an academic setting, let alone a workplace setting, these women's experiences reveal the potentials for team interactions when gender bias is removed. One woman shared about one such experience in her undergraduate coursework and why it was so positive. She believed that it was so positive because she was able to choose her team, and they all knew each other well from past coursework:

> I think [one reason it was positive was] getting to choose your group, especially in a program where you've all been taking classes together for a few years. So […] everyone getting to choose your own group was really nice. You, you kind of know everyone's work style a little bit. Like I said, everyone kind of knew what they were comfortable with. And we kind of just, I don't know, it went really smooth. We, like I said, they all had sections that they really wanted to work on. And there was some overlap, but we were all very comfortable writing together. And yeah, it was it was very smooth.

This participant was conscious that gender likely played a role—she noted that she could work just as well with all the women in her cohort, but she knew there were at least a few men that she would not have been able to have this kind of positive collaboration with. She later noted that "I definitely would say that I have had better collaborative writing experiences in groups that at least have one other woman on them." She was quick to bring up that she thought that this could be her own bias; however, in past experiences on teams where she is the only woman, she noted that "sometimes I feel like if I have a question, or if I have a criticism, that sometimes it is taken as more of an attack. And I feel like when there's other women in the group, it's generally taken as a criticism and not as an attack." Thus, when the team only included women, it contributed to all of the members of the team feeling more comfortable voicing ideas and criticism, asking

questions, or taking action to revise a piece of writing. When asked why she felt that was the case, she responded:

> I think it was kind of a mutual respect thing. We all, all four of us were very comfortable in each other's status as engineers, and in our own, we didn't feel like attacked by anyone in the group or anything. And I think the way that that stuff was said was really helpful. […] It's like the difference between criticism and constructive criticism. I think it was all very, very constructive, and came from a place of wanting the project to do better and not just not, not putting people down, I guess.

Another participant echoed this experience of mutual respect when talking about how her team would share ideas:

> I think we're all really comfortable, like sharing with each other and even being like, oh, that sounds really cool, but I think that idea kind of sucks. […] Not like, not like we say that [an idea sucks], but like, I feel like we can be honest and be like, oh, like, I'm not sure if that's gonna work out. […] And I feel like it's also like […] if I shared an idea on something, and they both kind of shot it down, like I wouldn't be like, "Oh, they're just not listening to me." Like, I feel like, we all really listen to each other well […]. And we came up with, like, a really thought-out, detailed project plan. And we've gotten good grades on everything. So I think we just work well together. And it's really easy. Like, it doesn't really seem like this huge task to work with them.

In general, the participants who were women and who had a chance to work with other women found those experiences to be more positive because not only did it lead to stronger projects, but they also enjoyed the experience. They spoke of the ease of the collaboration and the ways the project became more fun:

> I guess just because of our dynamic, like, we can sit there and talk about stuff and go, just go sit down and like chit chat while also actually getting our stuff done. And there's no level of like […] uncomfortableness with it, I guess. And, um, we're all like really good about throwing in these ideas. And it's almost like, fun to listen to people that like I care about […] as friends, like, come up with these like good ideas for our project. And like seeing these things, like work out.

The women trusted each other, were able to feel like they could contribute, and they were able to push against ideas and critique aspects of others' work, or share knowledge with each other, leading to a final product the participants could be proud of. In these teams, they felt more able to tap into the power of collaboration that is essential for engineering workplaces—and they enjoyed their experience.

Faculty Framing
Relatedly, another revealing finding was the disparity in which faculty think about diversity, equity, and inclusion (DEI) in teaching teamwork—and which do not. When asked, some faculty were able to clearly articulate how they use DEI to guide their teaching to varying degrees, while others were less able to do so. For those unable to articulate the connections, it wasn't that they

weren't considering DEI work in the context of engineering; they simply were not connecting it directly to their teaching practices. These individuals thought of themselves as committed and caring educators and used practices that supported student success, but they did not frame their teaching as explicitly focused on equity and inclusion.

The tendency to frame specific educational practices as simply *good teaching* reveals potentials as well as missed opportunities. The potentials are that these faculty are already using evidence-based instructional practices aimed at supporting learning in the classroom. These faculty are also thinking carefully about what impactful learning looks like and can be. The missed opportunity, however, is in understanding these practices as also supporting underrepresented students in the classroom; faculty who can think about their practices in terms of DEI will be more likely to correct for bias or address issues on team projects resulting from implicit bias.

Recommendations for Teaching with Collaboration
Based on these preliminary findings and analysis, faculty can create more supportive teamwork environments in their classroom in ways that center equity and inclusion. This section offers recommendations for faculty drawn from student experiences and the literature on evidence-based instructional practices. Overall, these recommendations aim to improve the experiences of all students participating in team projects, while also amplifying strategies to support underrepresented students, and they align with current research on creating inclusive teams [19, 21].

Structure collaborative assignments
In the data, participants shared the benefits of structured teamwork settings—and the disadvantages of projects that felt unstructured. While some instructors may believe that providing structure reduces opportunities for students to build effective teamwork and project management skills, structure is necessary for the success of a project. This structure can also provide outlets for students experiencing bias or discrimination, or interpersonal conflict that may be related to a student's background/identities. How faculty choose to structure assignments depends on students' level and how teamwork/collaboration has been scaffolded through the curriculum or the number of opportunities to collaborate. However, some structure should be in place for all projects, including the following elements:
- *Team-building documents*: a team charter, a goal-setting document, or other ways to capture the goals, commitment level, and roles for each team member
- *Project management tools*: a task schedule, meeting minutes, and agendas to help manage tasks and communicate progress among the team and between team and instructor
- *Peer-evaluation tools*: opportunities to evaluate periodically during a project (for a lengthy project) and/or at the end of a project (for a shorter project)

These documents provide heuristics for teams to work through, which allows them to build trust. Furthermore, these tools ask participants to communicate about aspects of collaboration that may be left implicit and thus lead to conflict. Finally, these documents allow teams to anticipate the kinds of conflicts they may encounter and create a set of procedures for handling those conflicts, meaning that students are not left to figure out what to do when conflict arises or when a teammate stops contributing. Project management tools and peer evaluation tools also offer ways for students to record decisions in meetings and set meeting agendas (thus, supporting more

effective and efficient meetings) and opportunities to share feedback with each other and their instructor.

Create team building opportunities
The recommendation above is meant to provide the tools and structure to facilitate successful teams; this recommendation is focused on using those tools alongside other methods to create trust and community on the teams. Team building opportunities might include activities that focus on individual approaches and styles, such as the Clifton Strengths Builder or any of the other inventories that aim to reveal working styles and communication preferences. These individual inventories can then be used to reveal what the commonalities are among the styles and preferences in the group—and where differences exist that may lead to miscommunication or conflict. Other team building exercises might also include a focus on bias as well as team conflict, asking teams to look at scenarios and come up with approaches and solutions.

Provide regular check-ins for students
Regular instructor check-ins or communication was one strategy that a number of student/alumni study participants requested or pointed out as being helpful. Essentially, the participants felt that if they had frequent opportunities to connect individually with their professors, and if their professors had a chance to observe the teams working together, then the students could surface concerns earlier before it became a significant problem. In addition, they felt that regular communication ensured that when a problem was raised, the instructor was already conscious of the dynamics, and the situation was less surprising to the faculty member. These check-ins occur through the meeting minutes students create, meetings with individual students, periodic peer reviews (particularly for a lengthy project, like a semester- or year-long capstone), and regular team check-ins or observations.

Timing of these check-ins should be based on the length and duration of the project. For instance, for a semester (or year-long) team project, frequent early check-ins with both the team and individual students might be useful during the first month or so of a project as teams get to know one another and create their task schedules. At this phase, weekly check-ins with both full teams and individual students would allow instructors to intervene if task allocation seems inequitable and ensure each team member's goals are made explicit, implementing suggestions by Fowler and Su [19]. These more frequent check-ins early in the project will also allow instructors to demonstrate their commitment to equitable team spaces, and they would allow underrepresented students to develop trust in their instructors and to feel comfortable bringing up any concerns. Once the teams seem to be working together effectively, these check-ins could move to every other week or once a month for longer projects, and they could be conducted through reviewing team meeting minutes or via email, or through periodic peer reviews. Shorter projects may not need as much support, and check-ins could occur during class meeting times as well as via peer review forms or over email.

Consider background/identity when forming teams
According to several studies, team composition can affect how minoritized students experience collaboration, and it can support or undermine their self-efficacy [19, 21, 30-31]. While an instructor should never segregate a team by gender, an instructor might aim place two women on a team, particularly for individuals who haven't worked together before. Likewise, team

formation could factor in similarities in other identities, such as racial/ethnic background. For underrepresented participants, having another teammate who shares some identity or background can help them communicate more clearly or feel less exposed to racial or gender bias on the team [19, 21]. For example, for women, having another woman on the team creates enough of a balance that their male peers may reconsider before saying something inappropriate, or they can support each other if something is said or done that they need to take to the instructor.

Highlight the sources of bias and how to correct for them
However, instructors must work to make students more aware of the sources of bias in team settings and how they can correct for them. Participants shared experiences in the interviews where when they took an issue of bias to an instructor, the instructor responded with shock and seemed to almost overreact to the situation. These participants noted that faculty seemed unprepared to handle the presence of overt sexism/racism or other forms of bias on teams, and their response to the student was not helpful. The suggestion these participants offered was that instructors should not only be ready to handle these situations but do more to prepare students for them. This focus can be part of the teambuilding process, where teams are presented with scenarios and asked to identify what is happening and how to resolve it; instructors can also name the sorts of patterns that are consistent with research on underrepresented students' experiences on teams. Finally, instructors can provide a clear mechanism for reporting such instances, signaling to the underrepresented or minoritized students in the classroom that these situations will be taken seriously and handled swiftly.

Reflect on teaching practices
Ultimately, instructors must be aware not only of the patterns of bias students may experience in team settings, but also of their own biases. Thus, instructors also need to do their own reflection about their experiences, their teaching practices, and where they hold biases. This reflection can include identifying areas where teaching and work practices align with equity/inclusion, where they could be more intentionally equitable in the classroom or in interacting with students, and where they may be unintentionally contributing to bias. This reflection can be facilitated through reading, participating in professional development opportunities, and working with other faculty committed to creating more inclusive engineering classes. While not always easy to do, reflecting in these areas will create more awareness and lead to better student experiences.

Conclusion
In the scholarship on collaboration and communication in engineering contexts, many researchers focus on various problems on teams, but less frequently through the lens of equity and inclusion. This paper focuses on centering the experiences of underrepresented students. Essentially, by centering those experiences, researchers and instructors can determine the factors that create positive experiences, while also determining the impacts of negative experiences that may disproportionately impact women, racially minoritized students, and other underrepresented engineering students. By centering equity and inclusion, we also reframe these experiences as the product of cultural and social factors rather than individual problems. Subsequently, if we view these experiences in the context of the culture of engineering, by addressing the problems that emerge, we not only support all students in having productive and positive team experiences, but we also pinpoint what leads to bias. And ultimately, if we shift our practices to address these cultural factors and sources of bias, we employ the inclusive practices that have a chance to

increase retention and reduce bias and discrimination not only in the classroom but in the engineering workplaces beyond.

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Appendix A—Preliminary Survey Questions

Student/Alumni Survey

Start of Block: Demographic Information

This first section asks for some demographic information. Your responses here will provide background for your subsequent interview. Keep in mind that you may skip questions at any time or choose not to answer. I ask for your name here so that I can connect these responses to your interview; however, your responses will be kept confidential and your identity protected.

Q1 What is your name?

_____

Q2 What degree(s) have you earned? Check all that apply

☐ Bachelor of Arts (BA) (1)

☐ Bachelor of Science (BS) (2)

☐ Master of Arts (MA) (3)

☐ Master of Science (MS) (4)

☐ Other(s) (5) _____

Q3 What were your major(s) and minor(s)/any additional certificates you earned?

_____

Q4 When did you earn your most recent degree?

☐ 2019 (6)

☐ 2020 (7)

☐ 2021 (8)

☐ Currently a student

Q5 If you're currently still a student, what level are you?

☐   sophomore

☐   junior

☐   senior

☐   graduate student

Q6 Select your age range

○ 18 - 24 (1)

○ 25 - 34 (2)

○ 35 - 44 (3)

○ 45 - 54 (4)

○ 55 or older (5)

Q7 What is your gender identification?

○ Male (1)

○ Female (2)

○ Non-binary (3)

○ Identification not listed (use box to include) (4)

_____

○ Prefer not to say (5)

Q8 What is your ethnicity?

○ White (1)

○ Black or African American (2)

○ American Indian or Alaska Native (3)

○ Asian (4)

○ Native Hawaiian or Pacific Islander (5)

○ Other (6) _____

Q9 Do you identify as part of an underrepresented or minoritized group in engineering? If so, why? (e.g. have a disability, part of a racially minoritized group, based on gender identity). Feel free to skip the explanation if you wish not answer with specifics.

End of Block: Demographic Information

Start of Block: Block 2
This section of the survey asks for some background on your writing experience for academic purposes. Here, writing is any communication through written words, inclusive of digital and print communications and regardless of purpose or level of formality.

For the purposes of this survey, **writing for academic purposes is any writing you did in college that was assigned to you by an instructor as an academic requirements**. This includes writing for classes; internships; and theses, capstone projects, portfolios, and/or graduation requirements.

Q10 What are some of the kinds of writing you do currently or have done recently, whether personal, professional, or academic? Choose all that apply:

☐ Emails (1)

☐ Research papers (2)

☐ Book reviews (3)

☐ Lab reports (4)

☐ Summaries (5)

☐ Personal essays (6)

☐ Persuasive essays (7)

☐ Short stories (8)

- [ ] Poems (9)

- [ ] Timed writing (10)

- [ ] Five-paragraph essays (11)

- [ ] Analytical essays (12)

- [ ] Free writing (13)

- [ ] Journals or logs (14)

- [ ] Annotated bibliographies (15)

- [ ] Blogs or Wikis (16)

- [ ] Web sites (17)

- [ ] Reflections (18)

- [ ] Resumes and/or cover letters (19)

- [ ] Poster presentations (20)

- [ ] Research proposals (21)

- [ ] Journal articles (22)

- [ ] Letters/memos (23)

- [ ] Reports (24)

- [ ] Articles (25)

- [ ] Brochures (26)

☐ PowerPoint presentations (27)

☐ Narratives (28)

☐ Information papers (29)

☐ Other (30)

Q11 What do you believe are your strengths as a writer **in college for academic purposes**? Check all that apply.

☐ Making an argument (1)

☐ Incorporating evidence/support/sources (2)

☐ Citation style (3)

☐ Organizing your writing (4)

☐ Finding sources (5)

☐ Evaluating sources (6)

☐ Understanding the assignment (7)

☐ Managing your time for an assignment (8)

☐ Revising your writing (9)

☐ Proofreading and editing your writing (10)

☐ Formatting your assignments (11)

☐ Writing with others (12)

☐ Understanding of different types of documents/writing (13)

☐ Developing your ideas (14)

☐ Writing multi-page/multi-paragraph papers (15)

☐ Writing concisely (16)

☐ Writing clearly (17)

☐ Using correct grammar and punctuation (18)

☐ Style (19)

☐ Voice (20)

☐ Other (21)

Q12 What did you find challenging about writing **in college for academic purposes**?

☐ Making an argument (1)

☐ Incorporating evidence/support/sources (2)

☐ Citation style (3)

☐ Organizing your writing (4)

☐ Finding sources (5)

☐ Evaluating sources (6)

☐ Understanding the assignment (7)

☐ Managing your time for an assignment (8)

☐ Revising your writing (9)

☐ Proofreading and editing your writing (10)

☐ Formatting your assignments (11)

☐ Writing with others (12)

☐ Understanding of different types of documents/writing (13)

☐ Developing your ideas (14)

☐ Writing multi-page/multi-paragraph papers (15)

☐ Writing concisely (16)

☐ Writing clearly (17)

☐ Using correct grammar and punctuation (18)

☐ Style (19)

☐ Voice (20)

☐ Other (21)

Q13 In general, how confident did you feel in completing **academic writing tasks** in college?

○ Very confident (1)

○ Somewhat confident (2)

○ Neither confident nor not confident (3)

○ Not confident (4)

○ Not at all confident (5)

Q14 What contributed to your feelings of confidence?

_____

End of Block: Block 2

Start of Block: Block 3

For the last section of this survey, I ask you to reflect on writing as an individual and on a team

Q15 In your most recent semester (or final semester if you've graduated), how many course projects did you complete that involved writing? Briefly describe the project(s).

Q16 How many of these writing projects were collaborative (e.g. the written product was submitted by a group, or the technical work was completed as a group)?

Q17 How much other recent collaborative writing have you done outside of coursework (such as personal or professional work)? Give a few examples, if relevant.

Q18 On a scale of 1 to 5, how comfortable do you feel in your ability to collaborate successfully?

Q19 On a scale of 1 to 5, how much do you enjoy collaborative writing projects?

Q20 Briefly explain your rating for both your level of comfort and your enjoyment.

Q21 What do you see as the primary benefits of collaborative writing projects?
- Learn from others, both on technical and writing elements
- Less work than an individual project
- Better final project than individual efforts
- Support from peers
- Variety of roles and ways to contribute
- Professor provided guidance and support
- Opportunities to develop collaboration/teamwork skills
- Chance to write with others
- Held accountable by team
- Other (blank to include answer)

Q22 What do you see as the primary drawbacks? Choose no more than three.
- Slackers/loafers
- Being forced into roles
- Having to do more than my share
- Not everyone shares the same goals
- Differing ideas about high quality
- Professor doesn't teach effective teamwork skills
- Split or division between technical and communication tasks

- Not getting to do technical elements
- Being forced into managing the project
- Not being recognized for the work I do
- One person takes over the writing
- Peers ignore feedback from team/professor
- Writing seems like an afterthought and is completed last minute
- Other (blank to include answer)

Thank you for your time! I look forward to talking more in our interview.

Faculty Survey

Block 1: Demographic Information

This first section asks for some demographic information. Your responses here will provide background for your subsequent interview. Keep in mind that you may skip questions at any time or choose not to answer. I ask for your name here so that I can connect these responses to your interview; however, your responses will be kept confidential and your identity protected.

1. What is your name?
2. What degrees have you earned?
3. What is your current job title/position?
4. Select your age range
   a. 25-34
   b. 35-44
   c. 45-54
   d. 55 or older
5. What is your gender identification?
   a. Male
   b. Female
   c. Non-binary
   d. Identification not listed (use box to include)
   e. Prefer not to say
6. What is your ethnicity?
   a. White
   b. Black or African American
   c. American Indian or Alaska Native
   d. Asian
   e. Native Hawaiian or Pacific Islander
   f. Other (box to include)
7. Do you identify as part of an underrepresented or minoritized group in engineering?
8. If so, why? (e.g. have a disability, part of a racially minoritized group, based on gender identity). Feel free to skip the explanation if you do not wish to answer with specific details.

Block 2 Educational Experience

This section asks for some information about your experiences as a student.

9. When you were an undergraduate and/or graduate student, what **direct writing instruction** did you receive? Check any/all that apply
   a. First-year writing courses
   b. Technical communication courses
   c. Writing assignments within engineering courses with instruction on writing included
   d. Writing assignments within engineering courses with minimal teaching on writing
   e. Peer tutoring/support
   f. Integrated writing/engineering courses (e.g. an engineering course with a writing faculty embedded or included to teach writing)
   g. Other (blank to include)
10. As an undergraduate/graduate student, what **indirect writing instruction** did you receive?
   a. Feedback/support from lab peers on writing
   b. Faculty mentorship through feedback on writing outside of a course
   c. Supervisor/adviser feedback on writing
   d. Examples, models, and/or templates
   e. Self-identified resources (such as books, websites, etc)
   f. Other (blank to include)
11. What are some of the kinds of writing you do currently or have done recently, whether personal, professional, or academic? Choose all that apply:
   a. Emails (1)
   b. Research papers (2)
   c. Book reviews (3)
   d. Lab reports (4)
   e. Summaries (5)
   f. Personal essays (6)
   g. Persuasive essays (7)
   h. Short stories (8)
   i. Poems (9)
   j. Timed writing (10)
   k. Five-paragraph essays (11)
   l. Analytical essays (12)
   m. Free writing (13)
   n. Journals or logs (14)
   o. Annotated bibliographies (15)
   p. Blogs or Wikis (16)
   q. Web sites (17)
   r. Reflections (18)
   s. Resumes and/or cover letters (19)
   t. Poster presentations (20)
   u. Research proposals (21)
   v. Journal articles (22)
   w. Letters/memos (23)
   x. Reports (24)
   y. Articles (25)

      z. Brochures (26)
      aa. PowerPoint presentations (27)
      bb. Narratives (28)
      cc. Information papers (29)
      dd. Other (30)

12. In general, how confident are you in completing writing tasks, whether personal or professional?
      a. Very confident (1)
      b. Somewhat confident (2)
      c. Neither confident nor not confident (3)
      d. Not confident (4)
      e. Not at all confident (5)

13. What contributes to your confidence level or feelings of confidence?

14. From your education (undergraduate and/or graduate), what are 2-3 significant experiences you had that helped you develop skills in writing/communication?

Appendix B—Interview Questions
Student Interview
1. Why do you think engineering courses include collaborative projects with writing? How do these assignments meet your own learning goals?
2. Describe 2-3 of your most memorable collaborative writing experiences. What was the project's goals and context? What was your role? Why was it memorable?
3. In your collaborative experiences, what roles do you tend to take on? What do you see as your strengths as a collaborator and writer?
4. What do you see as your weaknesses as a collaborator and writer?
5. Name the most positive experience you've had with collaboration that involved a written part. Why was it so positive? What was the impact of this experience on your learning or work?
6. What are some other positive experiences you've had when working with/writing with others? Why were they positive?
7. Name the most negative experience you've had with collaboration. Why was it so negative? What was the impact of this experience on your learning or work?
8. What are some other negative experiences you've had when working with/writing with others? Why were they negative?
9. What might have helped those experiences be more positive?
10. What support would have been helpful during your negative experiences? What resources, instruction, mentoring, or other elements do you wish your instructor had provided?
11. What did you instructors do to support your team project experiences? Name any resources, direct instruction, mentoring, or other elements that they included.
12. How was your work typically assessed or graded? What elements seemed most important for earning a good grade?
13. Did you ever have faculty directly teach how to collaborate successfully? If so, where and how did you receive teaching on how to collaborate successfully? If not, why not?
14. In your collaboration experiences or team writing situations, have you experienced anything that felt like the result of implicit biases or stereotypes emerging from your background or identities? (E.g. getting asked to take notes because you were the only woman on the team). Who did these biases emerge from (e.g. faculty, students, or project sponsors)?
15. If you did connect these experiences to biases, how did you respond? Did you seek out support or resources? What was the response?
16. What do you think faculty should know about how to support students who are minoritized to help them have the best experiences with collaborative writing experiences?
17. What do you think all engineering students should learn and/or know about how to be productive members of teams?

Faculty Interview
1. In classes you typically teach, what are ways you include writing/communication assignments and instruction on communication in engineering?

2. When you include writing assignments, what are your main goals or reasons for including these assignments?
3. How comfortable or confident do you feel in your ability to teach writing/communication in your classes?
4. What are the key criteria for successful writing that you look for when you assess student work?
5. How successful are students in meeting your criteria for successful writing? Where do they typically struggle?
6. In the courses you teach most frequently, what kinds of collaboration do you assign? What kinds of writing do students produce?
7. What do you see as your strengths in teaching collaboration and team writing?
8. What teaching and/or support/resources do you provide students around successful collaboration and effective writing?
9. How frequently do you encounter team conflict (or learn about it)? What do you see as key common points of conflict? How were some of those conflicts resolved?
10. In conflicts among students cannot be resolved, how do you address them?
11. What is your approach to assessing collaborative projects and written work?
12. What areas do you want to improve on or learn more about in teaching writing/communication and/or collaboration?
13. How often do you see students experience biases during collaboration based on their identity or other factors? What do you do to address those biases?
14. As an instructor, what biases do you encounter from students and how do you address those biases?
15. In what ways do you consider equity and inclusion in creating your writing assignments and assessing writing/collaborative work?
16. What would be helpful or beneficial to support your efforts to incorporate collaboration/writing in your classes?
17. What would be helpful or beneficial to help you create more equitable and inclusive classes?