Promoting Inclusion Through Participation in and Construction of Engineering Judgments

Rachel C. Riedner and Royce A. Francis
The George Washington University

Marie C. Paretti
Virginia Tech

There has been significant research scholarship that reports on differential treatment of STEM students and faculty around race, gender, ethnicity, and other social categories (Tonso, 2006; Foor et al., 2007; McGee & Martin, 2011; Secules et al., 2021). As one example, Mary Blair-Loy and Erin A. Clef (2022) provide an important study of culture around scientific merit, which devalues the contributions of faculty women and people of color. As Blair-Loy and Clef point out, it is important to respond to differential treatment as well as research and document this treatment. Aligned with Blair-Loy and Clef's emphasis on responding, our chapter focuses on creating inclusive classroom practices in engineering classrooms. This chapter discusses the goal of promoting inclusion by supporting engineering students to recognize their own capacities, each other's capacities, and the social and discursive contexts in which they learn and work—a concept that we call engineering judgment.

The chapter takes engineering judgment as a starting point for discussions of recognition and inclusion in engineering classrooms. In previous work, we have discussed engineering judgment as a holistic, participatory capacity that integrates the technical and social context of engineering work, the cultural and discursive production of professional identities, and the cognitive processes underpinning naturalistic decision making (Francis et al., 2022). This previous work situates engineering judgment as a learning process through which students come to recognize a range of patterns and social practices as they accumulate decision-making experience over the course of their career trajectories. However, the capacity to learn judgment, as we expand upon below, rests upon students being included and recognized in engineering classrooms.

This chapter brings recognition into the conversation of engineering judgment. It argues that participation in engineering judgment practice requires a learning process and pedagogical structure where a student attains both recognition from others and self-recognition that they are a legitimate participant in engineering

DOI: https://doi.org/10.37514/ATD-B.2024.2364.2.11

work. In learning structures that support the development of engineering judgment capacity, students are recognized by their peers, faculty, and professionals as engineers when they exercise engineering judgment and when they are able to successfully communicate their judgment to multiple audiences.

We add to previous discussions the idea that such learning requires recognition by others. In an engineering context, discussion of recognition by self and others raises questions about who is included as contributing to learning, and more specifically, how recognition is situated within micro contexts (i.e., classrooms and teamwork) and macro contexts (i.e., larger social structures and histories in which learning takes place). Recognition as an aspect of engineering judgment and an aspect of engineering education more broadly, therefore, draws attention to inclusion and belonging and, concurrently, to marginalization and exclusion in the contexts of engineering education.

To extend this discussion of recognition, this chapter puts engineering judgment in conversation with scholarship on belonging and inclusion, as well as marginalization and exclusion, that are currently circulating in multiple disciplinary spaces, including rhetoric and composition and engineering education. Building upon data collected from student interviews, the chapter concludes by pointing out the need for classroom strategies that acknowledge, foreground, and integrate practices that enable recognition and inclusive learning of engineering judgment.

Judgment and Recognition

Engineering judgment is an important concept because it addresses how students are taught capacities to participate in professional life and to identify as engineers. Previous research has argued that engineering judgment as a capacity, an individual skill, or self-understanding can be taught and learned through embedded writing assignments where the process of developing reports, presentations, and posters about ongoing projects creates contexts that require students to exercise and justify a range of decisions (Francis et al., 2020; Francis et al., 2021; Paretti et al., 2019).

Elsewhere, we have developed the concept of engineering judgment by drawing from frameworks of academic literacies (e.g., Lea, 1998; Lea & Street, 1998), discourse identities (Gee, 2000), and naturalistic decision making (Mosier et al., 2018). Taken together, these theoretical frameworks describe how students develop fluency for participating in the discourse of their discipline and thus create a sense of belonging in the discipline. This approach to engineering judgment involves not only understanding the communicative language of the discipline but also addresses how students learn to express themselves through communicative forms appropriate to a task's context, purpose, and audience expectation (Carter, 2012; Mathison, 2019; Russell, 2002; Thaiss & Zawacki, 2006). This communicative

fluency is taught in writing in the disciplines (or WID) curriculum where, as Susan McLeod (2012) argues, faculty "teach students to observe disciplinary patterns in the way [that their language] is structured, helping students understand the various rhetorical moves that are accepted within particular discourse communities" (p. 59). Teaching the communicative practices and tasks of a disciplinary community teaches communicative conventions of a discipline, enabling students to identify and be recognized as part of the disciplinary community (see Allie et al., 2009, for a discussion of this process in engineering specifically).

Emphasizing the importance of explicit instruction in communicative conventions of disciplines, scholars in engineering education have pointed to the need for writing instruction that introduces students to the genres, recognizable rhetorical moves that achieve particular outcomes within disciplinary discourse (Berkenkotter et al., 1988; Miller, 1984; Russell, 1997). Scholars have argued that engineering disciplines with a focus on writing that include a nuanced concept of genre, audience, purpose, conventions, and attention to professional engineering contexts and traditions is a means of creating entrance into professional spaces and fields and for students to learn to identify as engineering professionals (Artemeva, 2007; Conrad, 2017; Dannels, 2000; Paretti, 2008). This scholarship has focused on how to make the teaching of writing in engineering contexts more nuanced by focusing on rhetorical awareness, where students learn to develop writing practices that respond to different audiences (Artemeva, 2005, 2007, 2009; Dannels, 2000, 2002, 2003; Paretti, 2006; Winsor, 1996). Rhetorical awareness suggests attention to genre conventions of the discipline, its purpose, goals, audiences, and other areas that may be implicit in written communicative practice but are essential for academic and professional success. The pedagogical goal is for students to learn and practice engineering judgment capacities through writing and for them to be recognized and self-recognize as having these capacities.

These observations that students develop engineering judgment and communicative capacities in which they are recognized as engineers suggest that writing skills (i.e., understanding and use of genre, audience, purpose) are a means through which students are recognized and recognize themselves as belonging to the engineering community of practice. When students learn forms of communication of their engineering discipline and use these forms of communication to make and communicate judgments, they see themselves and are seen by others as part of a disciplinary or professional community (Wenger, 1998). This recognition acknowledges student ability to apply and communicate specialized knowledge and analytic techniques to interpret information in ways that lead to meaningful engineering judgments. In other words, to be successful, students must be recognized by others (faculty and peers) and, thus, come to recognize themselves as individuals capable of exercising engineering judgments. Judgment, in this line of reasoning, is the capacity for understanding and responding to situations, adapting thinking,

making decisions, and communicating decisions. However, to exercise engineering judgment, students must demonstrate proficiency in these capacities in ways that are recognized by others, including their faculty and peers or other engineering professionals.

To summarize, in an engineering teaching context, developing and learning engineering judgment requires:

- Analytical skills: developing capacities to understand and respond to situations, to adapt thinking, and to make decisions;
- Rhetorical and communicative skills: understanding and use of genre, audience, purpose, etc.;
- Social context that enables these capacities to be developed creates opportunities for students to fully participate in learning and creates opportunities for students to be recognized as full participants.

This chapter develops the third area of engineering judgment: recognition. It draws upon scholarship in engineering education, rhetoric and composition, and other fields that are interested in processes of inclusion and exclusion, where gender, race, and other attributes designate some as inside a community while others are designated as outside of the community (Riedner, 2015; Young, 2003).

This expanded discussion of recognition places learning and teaching of engineering judgment in larger contexts than just classroom-level pedagogies or team building. In an engineering context, the valuation and worth of student work (grading, feedback, and other modes of evaluation), participation on teams, and contribution to labor of teams (including writing and analysis) all result in recognition of students as included (or excluded) members of the community. This process of recognition is thus situated within local sites of engineering contexts and broader educational and institutional contexts. Recognition occurs within social interactions among and between faculty and students, among individual students and student teams. Recognition also takes place within larger institutional contexts and histories, professional standards, and the wider social interactions and historical situations that provide the context in which learning and teaching take place. Recognition is situated within histories, structures, and discourses through which "individuals are socially assigned and ascribed" (McCall et al., 2020, p. 81). Thus, the teaching of engineering judgment—a learning process through which students come to recognize a range of patterns and social practices as they accumulate decision-making experience over the course of their career trajectories—must account for the social and discursive contexts in which students are included, excluded, or marginalized, and subsequently evaluated and valued.

To put it another way, recognition takes place in micro social contexts (classroom interactions, grading and other forms of evaluation, feedback from instructors and peers, support for awards and honors, letters of recommendation, etc.)

that resonate with macro educational structures, systems, traditions, and histories (Claris & Riley, 2012; Inoue, 2015). In order to teach engineering judgment so that students achieve recognition of their participation in disciplinary communities and for students to see themselves as members of their disciplinary communities, engineering educators must understand both the micro and macro social and written and oral communicative contexts in which classroom teaching and teamwork take place. Even more specifically, engineering educators need to understand how micro and macro contexts impact recognition of students themselves and their contributions to teamwork. To expand a discussion of micro and macro contexts in which engineering judgment is taught and learned and in which students are recognized as capable of engineering judgment, we turn to scholars of rhetoric and composition who argue that classroom-level practices and strategies are not removed from these larger systemic, structural, and historical contexts but in fact are deeply embedded within them (Inoue, 2015; Walsh, 1991). Our effort here is to understand and expand an understanding of how and where engineering judgment is taught by engaging with this scholarship and to understand the possibilities and constraints of recognition.

Social and Discursive Contexts of Teaching

The current moment, as Deborah Brandt (2015) argues, is a period of mass literacy where "the rise of mass writing has accompanied the emergence of the so-called knowledge or information economy" (p. 3). An information economy creates a context in which workers, nations, regions, industries, and globally minded universities, in some instances with directives from governments or professional organizations, shift their curriculum to facilitate acquisition of literacies to create curricula that will enable students to discern, use, apply, and communicate information—in other words, exercise judgments.

Brant's work allows us to approach teaching broadly as shaped by historical situations (p. 7), the particular political and national economies that necessitate the development and teaching of particular kinds of literacies and judgments. This contextual approach to teaching is echoed by Brian Street (2017), who points out that academic literacies take place within "social context and with cultural norms and discourses" (p. 24). More pointedly, as Street's work suggests, academic literacies are developed in contexts of multiple forms of power that are immersed in political economy and social worlds at the local, national, and global level (see also Burry et al., this collection). Power—in all its forms, institutional, historical, discursive, social forms organized around race, gender, and other social categories —is always present in educational settings, including classrooms, curricula, interactions, and scholarship (Inoue, 2015; Walsh, 1991). Social relations, multiple forms of power,

and economic forces shape the experiences that students bring to education and take from their education, the capacities for discernment they develop, the writing that they do, and the recognition and self-recognition they develop.

This understanding of teaching and classroom practice as situated within larger contexts resonates with scholarship in writing studies that emphasizes that educational practices and educational outcomes are deeply imbued in real, lived experiences. These experiences include work, class identity, racial, gender, disability, or other social formations, and are connected to the historical and the structural to the personal and the lived (Mohanty, 2003). As James P. Gee (2000) notes, constructions of [student] identity are always embedded in the socially and historically constructed community or cultural narratives that, to a large extent, shape the identities (discourse or otherwise) that are available to individuals and that individuals refer to and negotiate with. Focusing on the social and institutional features that constitute the context within which students learn, Karen Tonso's work on engineering identity looks at how social and institutional features, and in particular, language, create cultural spaces that yield particular expectations and pressures. These existing cultural forms define sets of norms and expectations that individuals engage with as they negotiate and construct their identities (Tonso, 2006, pp. 273-274).

Importantly, a substantial body of work in engineering education over the past decade or more has repeatedly demonstrated the ways in which these existing social practices exclude and marginalize students who do not fit what Alice L. Pawley (2019) refers to as the "ideal engineering student": "White, male, between the ages of 18–22, lives on campus and lacks major obligations such as full-time employment or family care" (p. 24). Tonso's ethnographic work of engineering student design in the early 2000s highlights the ways in which women (as well as men who do not fit key stereotypes) were both discursively and practically excluded from conceptions of what it means to be an engineer (Tonso, 2006, 2007). In her study of the identities used to describe engineering students at one public, engineering-focused university in the US, she found that collectively, the available set of terms and the images they invoked "gave unequivocal messages that women are generally not recognized *as engineers*" (Tonso, 2006, p. 292). Cynthia E. Foor, Susan E. Walden, and Deborah A. Trytten's (2007) seminal study of "Inez," a first-generation, multi-racial, low socio-economic status female engineering student uses critical cultural theory to demonstrate the ways in which students who are outside the dominant culture (white, middle-class, heterosexual, male) are othered and excluded from the culture of engineering programs. Using theories of intersectionality, Erin A. Cech and Tom J. Waidzunas (2009) highlighted the ways in which engineering culture is heteronormative, positioning homosexuality as incompatible with technical competence in their qualitative study of engineering students who identified as gay, lesbian, or bisexual. Ebony O. McGee and Danny B. Martin (2011), drawing on stereotype threat and critical race theory, detail the repeated exclusions experienced by Black

undergraduate students in mathematics and engineering at four universities in the Midwestern US as they confronted the implicit and often explicit stereotypes that suggest Black students cannot succeed in STEM fields despite years of work to develop and promote a more inclusive engineering culture. Recent work by Stephen Secules et al. (2021) on experiences of "professional shame" among engineering students demonstrates the ways in which students experience the social worlds of engineering differently based on their demographics, with women and racially diverse students demonstrating more awareness of the gendered and raced construction of norms and expectations in engineering. Moreover, these experiences extend into graduate education as well; quantitative research on engineering identity by Matthew Bahnson and colleagues (2012) found that white and male engineering graduate students experienced statistically significantly higher recognition of their engineering identity than female graduate students and graduate students of color. Across numerous quantitative and qualitative studies over time at a wide range of institutions, researchers continue to find that the socially constructed culture of engineering programs continually reproduces implicit biases, cultural norms and expectations, interpersonal interactions, uneven access to resources, and more that marginalize and exclude students who do not match the implicit white, male, middle-class, single, heterosexual norm.

Classroom learning and evaluation is addressed by Asao Inoue (2015), who discusses classroom ecologies, or material conditions and discursive contexts in which complex interactions take place that are influenced by local events and histories (pp. 77-86). Writers, as Inoue emphasizes, "learn to write in "real social contexts," with real people in mind as their audience, from real people's words about their words and worlds, from material action and exchange in material environments" (p. 91). Multiple, intersecting, and intersectional forces shape the institutional places and instructor approaches to the teaching of writing. As a formal curriculum—one that is authorized by institutional committees and by other authorizing bodies at universities, supported implicitly and explicitly by corporations, and sanctioned by nation-states—the lived experiences of writing are situated within complex contexts that link students and faculty to institutions and places; engineering exists in complex social and historical contexts. As Inoue argues, "environments," that is, economic, political, and historical contexts along with social beliefs and practices, all complex and intersecting forces, "affect people . . . as we dwell and labor because we dwell and labor in those places" (p. 79).

To expand this discussion, students learn, write, participate in teamwork, learn engineering judgment, and are assessed for their learning in socially constructed cultures of engineering programs. In terms of evaluation of student performance and valuation of student contribution, Inoue argues that assessments of student writing and classroom performance by instructors are located within racialized (and we add gendered) systems. Inoue observes that instructor assessment of student writing

performance is neither free of macro social ideas of race (and gender and other social designations) nor are they free of judgments about the appropriate or valued forms of creation and communication of knowledge. Assessment, he says, "ha[s] uneven effects on various groups of people . . . [and]privilege some students over others" (p. 19). Thus, assessing student writing and learning engineering judgment both take place within systems that are shot through with racialized and gendered meanings that can create marginalization and exclusion.

Judgment of Student Writing

Understanding the evaluation of student learning and student performance as a social activity that is part of larger, powerful structures that are present in micro-teaching contexts and classrooms raises questions about how students whose identities or whose contributions to teamwork do not fit the normative stereotype of engineering (this point will be elaborated below). Scholars in composition studies draw attention to obstacles that students who are underrepresented in STEM, minoritized students whose voices in STEM have been pushed to the margins, first-generation students, and other students face in writing classrooms that are not set up to recognize their knowledge, experience, or other mitigating factors that impact classroom participation.[1] This attention to how personal experiences of students, and their development of identities, is echoed in scholarship that considers the experiences of disabled students in engineering curricula. Cassandra McCall and colleagues (2020) suggest that students' ability to acquire professional identity can be impacted by disability. As they argue, "little work has examined the way students with disabilities experience, interpret, and engage the field to become professional engineers" (McCall et al., 2020, p.80).

Inoue and other writing studies scholars describe a felt sense of failure produced by teaching systems, pedagogical practices, and assessment of student writing that are not attentive to the knowledge and learning of minority students. To understand the broader context in which marginalization and exclusion take place in educational contexts, Inoue, therefore, looks to "broader patterns" (p. 21) and "historical exigencies" (p. 64) that influence the assessment of student writing. His

1 The position of students can vary depending upon institutional and other social contexts. Full participation requires recognition, and a minoritized individual is more at risk of not attaining that recognition. This is different from under-representation, which may relate to the number or proportion of individuals sharing an identity in a given context (e.g., African American, queer, male, etc.). For the purpose of discussing recognition, minoritization may be more relevant. For example, we are aware that a student who is minoritized at one institution may not be minoritized at another. As a result, it is important to attend to the particular institutional contexts and histories where teamwork takes place.

work investigates how assessment of student writing that does not understand student experience can have a negative impact on individual students and calls upon instructors to be "attentive to structural racism, the institutional kind . . . that makes many students of color like me when I was younger believe that their failures in school were purely due to their own lacking in ability, desire, or work ethic" (p. 4). Inoue asks teachers of writing to consider the evaluation and assessment of student materials, asking "how does a teacher not only do no harm through [their] writing assessments but promote social justice and equality" (p. 3).

Current conversations in composition studies suggest that teaching, including teaching in engineering contexts, must consider how instructor feedback can have a marginalizing impact on students whose experiences do not fit with social norms. How instructors respond to, assess, and communicate assessment of student writing can result in marginalization and exclusions that are linked to broader patterns, powerful structures, and embedded institutional practices.

This discussion impacts and develops how we view engineering judgment as a learned skill where students develop capacities to understand and respond to situations, to adapt thinking, and to make decisions and a learning process through which students come to recognize a range of patterns and social practices as they accumulate decision-making experience over the course of their career trajectories. To undertake a learning process where students learn engineering judgment necessitates consideration of how instructors recognize and evaluate student performance and how this recognition and evaluation can, as Inoue points out, impact student learning. At the micro level, how instructors evaluate student products and performance, provide feedback, guide (or fail to guide) teamwork, and understand and evaluate student contributions to teamwork can have a significant impact on student's development of engineering judgment. As we go on to discuss in the next section, the need for a focus on the social and institutional contexts in which judgment is learned is suggested by data we gathered from student interviews. This data indicates that processes of marginalization and exclusion are active in engineering teaching contexts.

Case Study in Student Engineering Judgment Experiences

In the larger research project that we are undertaking (IRB# NCR192007), we explore how students participate in the construction and communication of engineering judgments through their writing projects (Francis et al., 2022). Although a full discussion of this project is beyond the scope of this chapter, student interviews from this wider project suggest a need for discussion of processes of marginalization and exclusion that interfere with the acquisition of engineering judgment capacity. Our data come from students in a systems engineering senior project cohort of 2020-2021 at the first and second author's institution. The senior project course (i.e., capstone

course) holds a critical place in the undergraduate systems engineering curriculum, as it is the course that provides the most extensive integration of professional practice with mastery of foundational systems engineering science and concepts. Moreover, the systems engineering capstone course emphasizes teamwork and professional communication. Although the systems engineering students will have worked on several team projects by the time they have reached the capstone course, the senior project is unique in that it allows students full autonomy over their project selection, problem formulation, and course(s) of action. Thus, teams must work together to enact judgments and choices related to the type of project they'd like to construct, the problems they will focus on throughout that project in response to their key stakeholders' concerns, and the types of solutions they'd like to deliver.

Therefore, the data we collected provide in-depth insight into the construction and communication of engineering judgments by undergraduate students. Data were collected from 11 semi-structured interviews with six students enrolled in the systems engineering senior project. All of the students have received prior instruction in WID courses that focus on the application of risk, uncertainty, and statistical decision theory to engineering problems and have had prior experiences completing substantial semester-long projects in engineering teams. These projects have required the student participants to apply engineering judgment to problems with significant uncertainties and conflicting objectives.

Our analysis of this data has allowed us to explore the choices students express in their writing about their judgments, as well as the processes used to construct both the judgments and the written document. These data suggest several important subthemes instructors must be aware of when designing assignments, course objectives, or classroom experiences. For example, one important subtheme has emerged from the data collection that indicates possible processes of marginalization at work in the formation of teams and the evaluation of student contributions to teams by instructors. At least one student reported occasions where marginalization impacted team construction and how recognition influenced the steps taken when team members needed to resolve conflict or otherwise work through unspoken or implicit processes of marginalization to complete their work. For example:

> The teams—it was mostly—I liked working with [name redacted], so we decided that we were going to do something together. [Name redacted] was last man standing at some point, so we told him to join. And then there was [name redacted], who I think he joined late or something so he needed a team, and we had him come on board. So there was that. That's how the team came about.

This excerpt shows that some teams are the result of marginalized students being forced by circumstance to work together. The reasons these students were

unable to find teams are not clearly elucidated in the interviews. However, this brief thought shared by one of the participants points to a greater need for understanding how student project teams are formed and may indicate a lack of guidance from instructors about how students are included in teams.

Additionally, our data suggests that conflict resolution is another need from faculty that is potentially under-described in the corpus. Consider the following:

> At that point, I [pushed for] my team, I'm like I'm willing to change the whole thing myself. Just let me do it, because I feel like now that clarified a lot of things that maybe we were not getting, and I kind of—at the very end I saw where the issue was. My team was reluctant so there was a lot of dynamics where like, no, we don't want to change anything. My issue was we weren't changing anything and that wasn't taking us anywhere. Now that we've found the thing that gives us the best chance at understanding what it is that we should do, and we should actually do it, even if it means that there is a change [that's kind of my mentality is], I will work day in and day out to get it done. But they were like no, we don't want to change it. I understand, they didn't want to change everything so radically with only one submission left. So . . . Our paper was very patchy. I basically—I tried to incorporate the latest feedback that we got [in the sections that I wrote]. They were not on board, so half the paper was on one topic. The other one was all over the place. So, yeah, I totally understand why we didn't get the grade that we wanted.

Although conflict was not widely discussed in these interviews, this excerpt clearly shows that team dynamics affected judgments about the problem being formulated, the analyses being constructed, and the interpretation of those results that could be constructed by the team. In this excerpt, the student felt that the team should be more willing to make changes to their project scope and deliverables, even down to the last submission (e.g., "I understand, they didn't want to change everything so radically with only one submission left."). The student reported, "They were not on board, so half the paper was on one topic. The other one was all over the place."

As many scholars have argued in recent years, the marginalization and exclusion of students who do not fit the normative stereotype of engineering (i.e., white, male, cis-gendered, heterosexual) is a function of many facets of engineering culture that serve to continuously reproduce and validate some identities over others. Tonso's work on engineering identity production highlights the ways in which the cultural production of engineering identity often excludes women and some men, and work by Donna Riley, Amy E. Slaton, and Alice L. Pawley (2014), McCall et al. (2020),

Cech and Waidzunas (2011), McGee and Martin (2011), and others have similarly highlighted cultural exclusions along race, (dis)ability, and sexual orientation. In such environments, students need both guidance and support in exploring their own sense of identity, including both their personal understanding of self and their view of how they are viewed by others. There is a need for instructors and teaching assistants to play an explicit role in helping students understand how these cultural production dynamics influence engineering teamwork and knowledge production.

Consequently, it is increasingly important to help instructors and teaching assistants determine how identity production should intersect with team formation. Moreover, instructors and teaching assistants can help students to understand how identity production dynamics influence decision making within teams. This guidance is not external to the goals of teamwork; it is, in fact, fundamental to it due to its centrality in the construction of and participation in engineering judgment. If students are to develop the participatory capacity of engineering judgment, they must be recognized as legitimate contributors to their teams, and they must be fully included in teamwork. Because social and power dynamics can limit the recognition of some students' contributions to teamwork and can interfere with the learning of engineering judgments on the basis of the perception of identity, pedagogies of inclusion are central to this learning.

Inclusive Teaching

Our review of the data generated by our student interviews suggests some possible avenues of development of inclusive classroom practice that can support student learning. The second excerpt from a student interview demonstrates that teamwork often involves decision making and complex engineering judgments that require the collaborative participation of multiple team members. Engineering educators who aim to foster engineering judgment skills may consider guiding students throughout the teamwork process to explore intra-team dynamics *while* identifying some of the complex judgments teams will be required to make in order to complete their work. Our data suggest that these judgments include but are not limited to: understanding audience or framing important problems; selecting appropriate analytical methods or work processes; synthesizing and interpreting work products, including addressing unexpected research findings or scope changes; consulting clients, subject matter experts, or external resources; and, determining how, when, and to whom to communicate their findings or work products. These are complex tasks that necessitate a collaborative and inclusive approach to teamwork, which must be guided and cultivated.

Engineering judgment and intra-team dynamics are implicated in processes of recognition introduced earlier in this chapter and observed by other investigators

such as Tonso (2006). Recognition takes place within larger institutional contexts and histories, professional standards, and the wider social interactions, discourses, and historical situations that provide the context in which learning and teaching take place. Our data suggests that recognition occurs within and between teams as students build their own perceptions of who they and their peers are within the local social and cultural contexts they inhabit. These perceptions of each other can influence, as the second student quotation suggests, how the students choose whom to work with and how they delegate the roles and tasks that team members are responsible for within teams. These perceptions and decisions based upon these perceptions can influence the delegation of work and respect given to different contributions that are necessary for successful teamwork. Without explicit acknowledgment of social contexts that privilege certain groups over others, teamwork can contribute to practices of marginalization. Thus, the teaching of engineering judgment—and relatedly, guidance given to students about teamwork and the evaluation of individual student contributions—must account for the social and discursive contexts in which students are included, excluded, or marginalized, and subsequently evaluated and valued.

As our data suggests, engineering educators must be aware of how students recognize each other's professional skills and capacities and how this recognition is integrated into team dynamics and decisions. Pedagogical approaches that explicitly and carefully guide students to consider aspects of group formation, decomposition of work processes and synthesis of work products, and exploration of cultural, social, or political factors that influence and partially determine student work are key to promoting inclusion in the engineering classroom. This guidance is crucial for student learning because, as Scott Weedon (2019) observes and as our data suggests, engineering work is mediated through embodied and enacted communication practices. These communication practices have the potential to either be sites of recognition and inclusion or marginalization and exclusion. To account for social and discursive contexts and to promote inclusive practices, we put forward questions that provide a conceptual framework for teamwork design:

1. How might engineering educators design transparent pedagogical practices that address the micro (i.e., university culture, classroom dynamics) and macro (i.e., racial and gender dynamics) social contexts in which students develop engineering judgment capacities?
2. How might engineering educators design transparent pedagogical practices and assignments that enable students to recognize, address, and integrate differences among team members, recognize historical practices of marginalization, and develop a teamwork culture that cultivates full participation and recognition of the contributions of all team members (see Mallette, this collection)?

Instructor Assessment

How an instructor's view of student performance may be disconnected from actual student skills and disconnected from the dynamics of teamwork is another factor in creating more inclusive recognition. Tonso (2006) shows that student skills and capacities may be different from professor expectations or what an instructor recognizes or is able to see in her comparison of two student teammates, "Martin" and "Marianne" (pp. 293-297). First, Tonso notes that although Marianne possessed "technical skills that exceeded those of most senior students" (p. 293), Marianne's "being considered a bona fide engineer in the team did not carry over into her being considered that way" across a range of other situations in other courses and in on-campus recruitment by prospective employers (p. 294). Marianne's part-time job as a research assistant gave her real-world insights that made her better prepared than her teammates for design work and made her an indispensable part of her team whose work could not proceed without her input or authentication. Similarly, "Martin" was not known widely outside of his team (the same team as Marianne's) "as a 'star' student engineer *because he was not visible to faculty and administration*" (p. 295, italics added). Tonso notes that Martin did not participate in certain aspects of identity production that could have earned him greater recognition by declining to "exploit and control others, act as if he were superior to women in normative heterosexual relations, or beat his own drum" (p. 295). Instead, he "generously shared his work so teammates [whose other responsibilities interfered with project work] would have something to say during presentations to faculty and client" (p. 295). Tonso notes that Martin embodied "counter-hegemonic leadership" and "prototypically feminine practices during teamwork" (p. 296), including empowering and valuing teammates' voices and putting engineering work quality above classroom-required products. Importantly, Martin's leadership style contrasted with that modeled by at least one professor described by Tonso as recommending "a divide-and-conquer model where the leader cracked the whip and told teammates what to do" or with other more recognized students who were "doing very little themselves, telling others what to do, and later taking credit for that work" (p. 296).

This discussion from Tonso's work indicates three factors relevant to our discussion of how instructor perspective can impact student recognition. First, most student team dynamics are invisible to the professors and, in some cases, the clients who must evaluate the products of and the individuals constituting student teams. Next, the students who comprise student teams are evaluated both by professors and other students against recognized gender, racial, and other identities. Finally, faculty and clients who occupy positions of institutional authority recognize and legitimize a subset of the possible student identities available to each of the students. This has a range of implications for our discussion. On one hand, faculty and

instructors are important agents in the curation and reproduction of recognized campus engineer identities because they incentivize and legitimize certain roles or types. In this case, both Marianne and Martin were not the types of students widely recognized as occupying the highest levels of the hierarchy described by Tonso, but both students developed a wider range of skills and capacities that are critical to engineering practice, such as teamwork than their peers who may have received more personal recognition from professors, clients—and possibly, prospective employers—than their accomplishments warranted. In concordance with Tonso's observations, our own data suggest that inter-dynamics of teamwork are more complex than an instructor may be aware of (or perhaps interested in). In assessing teams, the information that instructors have about individual student contributions may not recognize reality on the ground, particularly when that reality is intertwined with micro and macro social contexts and communicative practices that exclude certain student identities from processes of institutional recognition. Instructors need to understand that their own social context, their position of authority, and their insight into student dynamics may not align with student capacities or teamwork dynamics while providing a strong stimulus to the reification of processes of engineer identity recognition and legitimization.

Engineering educators might consider how to design transparent assignments and experiences that enable students to intentionally and reflexively engage in the processes of forming work teams, making decisions as a team, distributing work, or resolving team conflicts. As Jennifer Mallette argues in this collection, transparent course and assignment design is the practice of clearly communicating gloss, tasks, and evaluation criteria with the goal of inclusion for all students. These experiences or assignments could involve foregrounding recommendations about team decision making when data, tools, techniques, or findings conflict with *a priori* expectations. These experiences or assignments should also foreground how decisions are made by the team and how intra-team conflicts should be resolved. Many students do not receive explicit instruction in team dynamics, and such dynamics are among the key changes in the transition from school to work. For example, Ben Lutz and Marie C. Paretti (2021) point out that relationship building is critical to engineering work, where learning processes are "(mostly) informal, unstructured, sporadic, and motivated by production of goods or services." (p. 134). Their findings suggest that while students often wrestle with cultural and institutional factors during their schooling, assignment designs or experiences that explicitly highlight social processes at the organizational, workgroup, and interpersonal levels have the potential both for improved professional preparation and classroom inclusion.

There is extensive research from a number of fields that provides pedagogical guidance on how to set up productive teams that can come to collective decisions. For example, in their review of the literature on engineering and computer science project teams, Maura Borrego et al. (2013) suggest that team-based assignments

are effective for training in team-based skills such as communication and coordination and have the potential to involve interdependence among team members. The authors include several recommendations for instructors, including i) establishing activities for goal-setting and establishing team interaction rules, ii) project scaffolding, iii) guidelines for dealing with conflict, iv) guidelines for forming smaller teams (including trial periods and rules for switching members), v) exercises for developing mutual understanding and respect, and vi) utilizing grading schemes that motivate participation in team projects (Borrego et al., 2013, p. 497).

These findings suggest several important actions that can be taken by instructors who seek to create classrooms and course activities that foster inclusion. Assignments and classroom activities can be designed to address and provide guidance with areas that require engineering judgment, such as how to integrate feedback, how to make collective decisions, how to include all team members in decision making, how teams address unexpected results, dealing with uncertainty and ambiguity, and iteratively moving toward a solution as much as they are designed to assess the ability to understand and apply knowledge.

Instructors can begin by guiding students to develop a system of mutual accountability. This system of mutual accountability should be inclusive in assessing strengths and weaknesses of members, be aware of gendered perceptions of certain types of skills (such as writing tasks often assigned to women), and be inclusive of how different voices are acknowledged and heard. Race can also weigh in as teams can be a place where students experience microaggressions. If there is no way to get past biases and past experience, if there is no guidance on how to equitably distribute labor, then certain team members won't be considered for certain types of tasks, tasks may not be aligned with students' capacities, or students may not receive recognition for the work they in fact produce.

If engineering judgment involves learning to work through complexity and act, this capacity includes how teams of engineers work through complexity and act as a group in and through written language. The marginalization reflected by the first student quotation suggests that these key skills may not be learned by some students who are not included in teamwork or who are included as an afterthought. These skills may not be recognized by some students who, intentionally or unintentionally, exclude others from full participation in teamwork. As a result, guidance with inclusive participation and inclusive communication should not be an afterthought or left to chance but an explicit aspect of pre-professional pedagogical practice—including guidance on team formation, intra-team communication, teamwork decomposition and distribution, and other important judgment processes affected by the dynamics of recognition and inclusion.

To address these dynamics, assignments and classroom activities can address and provide guidance concerning the construction and communication of engineering judgments to audiences, including faculty evaluators and peer co-workers,

but with an eye to the wider range of audiences that students will interact with in the professional world and that can recognize student's capacity to enact engineering judgment. Although many students wish to create more inclusive learning and work environments, they need guidance on how to recognize their own capacities and experiences, how to recognize each other's capacities and experiences, and how to recognize the social and discursive contexts in which they learn and work. Students need to be guided to cultivate inclusivity and need resources to be capable and inclusive partners. Assignments can be designed to make students aware of the experiences of others and how those might influence engineering work products and judgment. Instructors can foreground the following questions as they design teamwork assignments: How can we guide the ways in which students manage their projects? How can we design assignments that draw out specific work processes and team contributions? How do we assess contributions to project formation and uncertainty management? How might we ask team members to assess their own skills before assigning tasks? How might assignments ask students to evaluate their own growth and learning?

Acknowledgments

This research is supported by the National Science Foundation (NSF) under Grant Numbers 1927035 and 1927096. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

Allie, S., Armien, M. N., Burgoyne, N., Case, J. M., Collier-Reed, B. I., Craig, T. S., Deacon, A., Fraser, D. M., Geyer, Z., Jacobs, C., Jawitz, J., Kloot, B., Kotta, L., Langdon, G., le Roux, K., Marshall, D., Mogashana, D., Shaw, C., Sheridan, G., & Wolmarans, N. (2009). Learning as acquiring a discursive identity through participation in a community: Improving student learning in engineering education. *European Journal of Engineering Education*, *34*(4), 359–367. https://doi.org/10.1080/10288457.2010.10740678

Artemeva, N. (2005). A time to speak, a time to act: A rhetorical genre analysis of a novice engineer's calculated risk taking. *Journal of Business and Technical Communication*, *19*(4), 389–421. https://doi.org/10.1177/1050651905278309

Artemeva, N. (2007, August). Becoming an engineering communicator: Novices learning engineering genres. In *4th International Symposium on Genre Studies* (pp. 15–18).

Artemeva, N. (2009). Stories of becoming: A study of novice engineers learning genres of their profession. In C. Bazerman, A. Bonini, & D. Figueiredo (Eds.), *Genre in a changing world*, pp. 158–178. The WAC Clearinghouse; Parlor Press.

https://www.doi.org/10.37514/PER-B.2009.2324.2.08
Bahnson, M., Perkins, H., Psugawa, M., Satterfield, D., Parker, M., Cass, C., & Kirn, A. (2012). Inequity in graduate engineering identity: Disciplinary differences and opportunity structures. *Journal of Engineering Education, 110*(4), 949–976. https://doi.org/10.1002/jee.20427
Blair-Loy, M., & Clef, E. (2022). *Misconceiving merit: Paradoxes of excellence and devotion in academic science and engineering*. University of Chicago Press.
Brandt, D. (2015). *The rise of writing: Redefining mass literacy*. Cambridge University Press.
Berkenkotter, C., Huckin, T. N., & Ackerman, J. (1988). Conventions, conversations, and the writer: Case study of a student in a rhetoric Ph.D. program. *Research in the Teaching of English*, *22*(1), 9–44. https://www.jstor.org/stable/40171130
Borrego, M., Karlin, J., McNair, L.D., & Beddoes, K. (2013). Team effectiveness theory from industrial and organizational psychology applied to engineering student project teams: A research review. *Journal of Engineering Education, 102*, 472–512. https://doi.org/10.1002/jee.20023
Carter, M. (2012). Ways of knowing, doing, and writing in the disciplines. In T. Myers Zawacki & P.M. Rogers (Eds.), *Writing across the curriculum: A critical sourcebook* (pp. 212–238). Bedford/St. Martin's.
Cech, E., & Waidzunas, T. (2011, June 14-17). *Engineers who happen to be gay: Lesbian, gay, and bisexual students' experiences in engineering*. [Conference presentation.] 2009 American Society for Engineering Education (ASEE) Annual Conference & Exposition, Austin, Texas. https://doi.org/10.18260/1-2--5583
Claris, L., & Riley, D. (2012). Situation critical: Critical theory and critical thinking in engineering education. *Engineering Studies 4*(2), 101–120. https://doi.org/10.1080/19378629.2011.649920
Conrad, S. (2017). A comparison of practitioner and student writing in civil engineering. *Journal of Engineering Education*, *106*(2), 191–217. https://doi.org/10.1002/jee.20161
Dannels, D. P. (2000). Learning to be professional: Technical classroom discourse, practice, and professional identity construction. *Journal of Business and Technical Communication*, *14*(1), 5–37. https://doi.org/10.1177/105065190001400101
Dannels, D. (2002). Communication across the curriculum and in the disciplines: Speaking in engineering. *Communication Education*, *51*(3), 254–268. https://doi.org/10.1080/03634520216513
Dannels, D. P. (2003). Teaching and learning design presentations in engineering: Contradictions between academic and workplace activity systems. *Journal of Business and Technical Communication*, *17*(2), 139–169. https://doi.org/10.1177/1050651902250946
Foor, C. E., Walden, S. E., & Trytten, D. A. (2007). "I wish that I belonged more in this whole engineering group:" Achieving individual diversity. *Journal of Engineering Education, 96*(2), 103–115. https://doi.org/10.1002/j.2168-9830.2007.tb00921.x
Francis, R., Paretti, M., & Riedner, R. (2020, October). *Exploring the role of engineering judgment in engineer identity formation through student technical reports*. [Conference presentation.] 2020 IEEE Frontiers in Education Conference (FIE).
Francis, R. A., Paretti, M. C., & Riedner, R. (2021, July). *Engineering judgment and decision making in undergraduate student writing.* [Conference presentation.] 2021 ASEE Virtual Annual Conference.
Francis, R., Paretti, M., Riedner, R. (2022). *The WRI2TES project: Writing research*

initiating identity transformation in engineering students. [Conference presentation.] The Proceedings of the American Society of Engineering Education 2022.

Gee, J. P. (2000). Chapter 3: Identity as an analytic lens for research in education. *Review of Research in Education*, *25*(1), 99–125. https://doi.org/10.3102/0091732X025001099

Inoue, A. B. (2015) *Antiracist writing assessment ecologies: Teaching and assessing writing for a socially just future*. The WAC Clearinghouse; University Press of Colorado. https://doi.org/10.37514/PER-B.2015.0698

Lea, M. (1998). Academic literacies and learning in higher education: Constructing knowledge through texts and experience. *Studies in the Education of Adults*, *30*(2), 156–171. https://doi.org/10.1080/02660830.1998.11730680

Lea, M. R., & Street, B. V. (1998). Student writing in higher education: An academic literacies approach. *Studies in Higher Education*, *23*(2), 157–172. https://doi.org/10.1080/03075079812331380364

Lutz, B., & Paretti, M. (2021). Exploring the social and cultural dimensions of learning for recent engineering graduates during the school-to-work transition. *Engineering Studies*, *13*(2), 132–157. https://doi.org/10.1080/19378629.2021.1957901

McCall, C., Shew, A., Simmons, D. Paretti, M, McNair, L. (2020). Exploring student disability and professional identity: Navigating sociocultural expectations in U.S. undergraduate civil engineering programs, *Australian Journal of Engineering Education*, *25*(1), 79–89. https://doi.org/10.1080/22054952.2020.1720434

McGee, E., & Martin, D. (2011) "You would not believe what i have to go through to prove my intellectual value!" Stereotype management among academically successful Black mathematicians and engineers. *American Educational Research Journal 48*(6), 1347–1389. https://doi.org/10.3102/0002831211423972

McLeod, S. (2012). The pedagogy of writing across the curriculum. In T. M. Zawacki & P. M. Rogers (Eds.), *Writing across the curriculum: A critical sourcebook,* (pp. 53–68). Bedford/St. Martin's.

Mathison, M. (Ed.). (2019). *Sojourning in disciplinary cultures: A case study of teaching writing in engineering*. Utah State University Press.

Miller, C. R. (1984). Rhetorical community: The cultural basis of genre. In A. Freedman & P. Medway (Eds.), *Genre and the new rhetoric*, pp. 67–78. Routledge.

Mohanty, C. (2003) *Feminism without borders: Decolonizing theory, practicing solidarity*. Duke University Press.

Mosier, K., Fischer, U., Hoffman, R. R., & Klein, G. (2018). Expert professional judgments and "naturalistic decision making." In K. A. Ericsson, R. R. Hoffman, A. Kozbelt, & A. M. Williams (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 453–475). https://doi.org/10.1017/9781316480748.025

Paretti, M. C. (2006). Audience awareness: Leveraging problem-based learning to teach workplace communication practices. *IEEE transactions on professional communication*, *49*(2), 189–198. https://doi.org/10.1109/TPC.2006.875083

Paretti, M. C. (2008). Teaching communication in capstone design: The role of the instructor in situated learning. *Journal of Engineering Education*, *97*(4), 491–503. https://doi.org/10.1002/j.2168-9830.2008.tb00995.x

Paretti, M. C., Eriksson, A., & Gustafsson, M. (2019). Faculty and student perceptions of the impacts of communication in the disciplines (CID) on students' development

as engineers. *IEEE Transactions on Professional Communication*, *62*(1), 27–42. https://doi.org/10.1109/TPC.2019.2893393

Pawley, A. (2019). Learning from small numbers: Studying ruling relations that gender and race the structure of U.S engineering education, *Journal of Engineering Education, 108*(1), 13–31. https://doi.org/10.1002/jee.20247

Riedner, R. (2015). *Writing neoliberal values: Rhetorical connectivities and globalized capitalism*. Palgrave Macmillan

Riley, D., Slaton, A., & Pawley, A. L. (2014). Social justice and inclusion: Women and minorities in engineering. In A. Johri & B. M. Olds (Eds.), *Cambridge handbook of engineering education research* (pp. 335–356). Cambridge University Press. https://doi.org/10.1017/CBO9781139013451.022

Russell, D. R. (1997). Rethinking genre in school and society: An activity theory analysis. *Written communication*, *14*(4), 504–554. https://doi.org/10.1177/0741088397014004004

Russell, D. R. (2002). *Writing in the academic disciplines: A curricular history*. Southern Illinois University Press.

Secules, S., McCall, C., Mejia, J. A., Beebe, C., Masters, A., Sánchez-Peña, M., & Svyantek, M. (2021). Positionality practices and dimensions of impact on equity research: A collaborative inquiry and call to the community. *Journal of Engineering Education. 110*(1), 19–43. https://doi.org/10.1002/jee.20377

Street, B. (2017). Can library use enhance intercultural education? In J. Pihl, K.S. van der Kooij, & T.C. Carlsten (Eds.), *Teacher and librarian partnerships in literary education in the 21st Century* (pp. 23–32). Sense Publishers.

Thaiss, C. J., & Zawacki, T. M. (2006). *Engaged writers and dynamic disciplines: Research on the academic writing life*. Boynton/Cook.

Tonso, K. L. (2006). Student engineers and engineer identity: campus engineer identities as figured world. *Cultural Studies of Science Education*, *1*, 273–307. https://doi.org/10.1007/s11422-005-9009-2

Tonso, K. L. (2007). *On the outskirts of engineering: Learning identity, gender, and power via engineering practice* (Vol. 6). Brill.

Weedon, S. (2019). The role of rhetoric in engineering judgment. *IEEE Transactions on Professional Communication, 62*(2), 165–177. https://doi.org/10.1109/TPC.2019.2900824

Walsh, C. (1991). *Pedagogy and the struggle for voice: Issues of language, power, and schooling for Puerto Ricans*. Bergin and Harvey.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press.

Winsor, D. A. (2013). *Writing like an engineer: A rhetorical education*. Routledge.

Young, I. (2003). From guilt to solidarity: Sweatshops and political responsibility. *Dissent 3,* 39–44. https://www.dissentmagazine.org/article/from-guilt-to-solidarity/