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Exploring the Social and Cultural Dimensions of Learning for Recent Engineering Graduates during the School-to-Work Transition

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ABSTRACT
The school-to-work transition is a challenging period for engineering graduates. In contrast to most engineering curricula, workplace learning involves organizations, people, cultures, and a range of non-technical and technical elements. Where many researchers have focused on skills gaps across school and work, we focus here on contexts gaps, or shifts in learning processes across organizational settings. Using reflective journals and semi-structured interviews, we explored significant learning events during recent engineering graduates' school-to-work transition. Using theories of organizational socialization, we characterize significant experiences related to social and cultural dimensions of participants' new organizational roles. Newcomers in this study reported learning related to, for example, forming relationships, learning local language, interacting with power structures, and other features of their organizations. Results offer points of contrast in which we compare learning processes and highight critical differences across school and workplace settings. Findings suggest that engineering educators should consider the broad spectrum of learning that takes place as graduates transition to their new professional roles. By better understanding the role of context in organizational learning, educators can more effectively prepare recent graduates for contemporary practice and develop a deeper appreciation for the interconnectedness of the social, cultural, and technical dimensions of engineering work.

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Introduction

One assumption underlying engineering education is that it prepares students for engineering work. Yet starting in 1918, reports have emerged periodically highlighting the underpreparedness of engineering graduates for work.[1] These reports identify gaps ranging from practical skills to communication to business acumen. But system-level analyses of school versus work suggest that the gap may be something other than missing skills; universities and workplaces are starkly different contexts.[2] Graduating engineers move from

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predictable school contexts and familiar student identities to widely varying roles in workplaces ranging from multi-national manufacturing companies to start-ups to consulting firms to government agencies.

This contextual shift demands a steep learning curve, even for students with prior work experiences.[3] In part this learning is technical; new engineers move from a broad undergraduate education to industry-specific technical depth. But the learning is also social and cultural as they adapt to new roles, organizational structures, relationships, work practices, modes of learning, and more. While the technical learning is certainly important, we focus here on the social and cultural dimensions as a compelling lens for exploring contextual differences and expanding our understanding of the relationship between school and work. We define social and cultural learning as those non-technical dimensions of learning (e.g. relationships, norms and values, modes of communication) that are embedded within and serve to contextualize technical engineering practice. Understanding these dimensions can help reframe the competency gap more accurately as a context gap, and help both sides better prepare students for the transition. To that end, we ask, How do recent engineering graduates describe significant learning related to social and cultural dimensions of their organization during the school-to-work transition?

Literature review

Changing contexts: school versus work

In moving from school to work, engineering graduates must adapt to organizational norms and values, acclimate to workplace cultures, and form interpersonal relationships—all while gaining job-specific technical competencies. The transition may be particularly difficult because engineering at work is a complex social activity with myriad social and technical constraints, but engineering in school focuses predominantly on technical content.[4]

Working engineers solve technical problems mediated by complex social interactions with heterogenous teams.[5] Bucciarelli argues that one important part of engineers' work, design, is a 'social process' that exists in a 'collective sense,' distributed among participants through social and technical coordination of activities and embodied in artifacts (e.g. reports, charts, products).[6] Empirical studies affirm this claim. For example, Anderson et al. found that practicing engineers saw themselves as a combination of problem solvers, team players, and lifelong learners.[7] Similarly, Trevelyan frames engineering practice as a 'human social performance.'[8] His research underscores the importance of social and cultural learning but also shows how practicing engineers often discount or minimize these dimensions of engineering work.[9]

This devaluing of social and cultural components results at least partly from the ways engineering is taught: most undergraduate programs emphasize technical problem-solving and minimize professional skills.[10] In school, students predominantly work on closed-ended, decontextualized textbook problems.[11] This technical focus trains them to separate 'real' engineering—calculations, CAD drawings, programming—from other dimensions of practice.[12] This separation, in addition to misrepresenting engineering work, also reproduces gender inequities and maintains barriers for those not performing the appropriate masculinity.[13]

In addition to perpetuating a false – and falsely hierarchical – binary between the technical and social dimensions of engineering work, the formal learning environment in school may also leave students underprepared for the structure and content of workplace learning. School treats learning as the primary goal and adopts modular, structured approaches: students move through courses in terms of discrete topics covered or book chapters read, and the new content intentionally builds on prior learning. Learning outcomes are specified *a priori* and assessed through assignments where students demonstrate those outcomes. As a result, recent graduates' beliefs about learning are often associated with structured classrooms, exams, and homework. And while research on informal learning demonstrates how students also learn through co- and extra-curricular experiences, along with informal out-of-class experiences, these are highly variable and the learning is often implicit; hence our comparisons here and throughout the paper focus on formal curricula that dominate undergraduate experiences and shape students' understanding of learning.[14]

In contrast, workplace learning often results from emergent processes that are not prescribed in advance or delineated (by, say, a syllabus) and that lack specified learning outcomes or formal assessments (e.g. exams).[15] Workplace learning is (mostly) informal, unstructured, sporadic, and motivated by production of goods or services.[16] For example, Korte et al. found that newcomer engineers expected formal, structured learning environments, but most often experienced 'informal, unstructured training experiences based largely in self-directed trial and error,' making the transition ambiguous and disorienting.[17] This incongruity results in confusion about what counts as learning and what can (and should) be learned in different settings, but also means that new engineers might not recognize the learning necessary to make sense of the social and cultural dimensions of their work.

As a result, not only do new graduates need to learn the technical complexities of their specific employer, they also need to acquire tacit social and cultural knowledge about engineering in practice and about their organizations, all in unfamiliar ways.[18]

School-to-work transitions

Despite the importance and complexity of the school-to-work transition, relevant research is limited.[19] Some of the most substantial work comes from the Academic Pathways Study, the Engineering Pathways Study, and the Professional Engineering Pathways Study.[20] For instance, Korte, Sheppard, and Jordan used social exchange theory to explore the early work experiences of recent engineering graduates.[21] Their results along with those of related studies point to the importance of forming social relationships and the influence of those relationships on workplace learning.[22] Internationally, Martin et al., in interviewing recent chemical engineering graduates in South Africa, identified strong interconnections across technical and social skills and highlighted graduates' self-reported lack of preparation for the professional dimensions of practice.[23] More recently, Paretti and colleagues, studying U.S. graduates, found that the most prominent challenges reported during engineers' first three months of work centered on teamwork, communication, and self-directed learning.[24]

Still, relatively little is known about the engineering school-to-work transition.[25] This neglect is particularly troubling in light of persistent narratives regarding a 'competency gap' among new graduates.[26] Within engineering, competency gap discussions center on professional skills such as communication, teamwork, and critical thinking. As early as 1918, the Mann Report highlighted gaps in both hands-on knowledge and the humanities. A hundred years later, ASME's Vision 2030 called for increased competence in 'communication, leadership, and creativity.' Empirial studies often focus on gaps in communication and teamwork among new engineers.[27] Despite scholarly critique of the competency gap,[28] academic and industry reports persistently treat the challenges new engineers face in the school-to-work transition as indicators of educational failures and needed curricular reform, with little attention to the contextual shifts graduates experience.[29]

While organizational transitions at any level necessarily involve new learning (e.g. understanding new company processes, navigating new colleagues' working styles), new engineers face specific challenges related to the nature of engineering practice and other information-driven, project-oriented work (e.g. coordinating work across diverse, distributed project teams; communicating technical information to colleagues at different organizational levels with different backgrounds; negotiating technical and social constraints in light of organizational goals and priorities). Little research to date has explored what new engineers learn with respect to such challenges. Yet these challenges, and reported 'competency gaps' that accompany them, are always embedded in specific contexts and dependent on local organizational knowledge of people, systems, and practices. Similar to arguments made by Jesiek, Buswell, and Nittala (this issue), understanding the school-to-work transition requires moving beyond notions of competency to include a deeper understanding of the contextual differences across these settings and the different spaces that engineers inhabit at work.[30] For example, a new graduate might recognize the need to tailor email based on audience, but to apply that principle at work, the graduate must first learn the communication needs and preferences of each new correspondent. Similarly, generalized principles for preparing meeting agendas must be tailored to the needs of specific teams and projects, which requires learning about the present social context. Without such local knowledge, successfully enacting these ostensibly missing skills, and acquiring new technical knowledge, is difficult if not impossible.

Conceptual framework: workplace learning content

To deepen our understanding of the school to work transition, we examine the social and cultural learning new engineers experience as they navigate across contexts. In doing so, we extend previous work that addresses the technical/social binary broadly or focuses on specific skills by focusing on the social and cultural learning of new graduates.[31] Our approach does not discount the intensive industry-specific technical knowledge new graduates learn. Recent work by Paretti et al. as well as by Lutz and others clearly demonstrates the importance of such learning.[32] Rather, we focus on the social and cultural dimensions because they help illuminate the extensive contextual differences new graduates encounter. Illuminating these dimensions is central to understanding the relationship between school and work, and in turn helping recent graduates more effectively navigate their transition.

To do so, we draw on research in organizational socialization (OS), paralleling the approach used by Beddoes (this issue).[33] In particular, we use the framework developed by Chao et al., which defines OS along six dimensions, five of which are social or cultural in nature (the sixth, performance proficiency, relates to learning technical job-specific tasks), as summarized in Table 1.[34]

Table 1. Content of workplace learning framework described by Chao et al. (1994).

Content Dimension	A priori Definition
History	Organization's customs, traditions, rituals, and other cultural knowledge.
Language	Technical language and jargon, slang, accepted modes of discourse that are unique to an organization.
Politics	Information regarding formal and informal work relationships and power structures. Information on who provides resources and of what kind.
People	Interpersonal learning associated with forming successful and satisfying work relationships.
Organizational Goals and Values	The culture and motives of a particular organization. Group or company norms, unspoken rules, informal networks.

While this framework does not represent *all* of the contextual differences between school and work, it provides a valuable lens for examining the kinds of context-dependent knowledge new engineers acquire during their transition and highlights some of the more prominent contextual gaps between school and work. Chao et al.'s framework, though developed more than twenty-five years ago, remains relevant and has informed numerous studies on newcomer adjustment, responses to organizational tactics, teamwork, and related transition issues.[35]

Methods

Our analysis draws from a multi-case study of mechanical engineering graduates.[36] Twelve new mechanical engineering graduates participated in interviews before graduation, responded to weekly reflective prompts for their first 12 weeks of work, and participated in follow-up interviews. We focus here on the weekly reflections and follow-up interviews. Analysis proceeded iteratively, starting with the *a priori* framework from Chao et al. and working recursively through the data to operationalize the constructs for this context.

Sample and data collection

Table 2 summarizes participants' backgrounds and Table 3 provides demographic information; to protect participants' identities, gender and race/ethnicity are not disaggregated. The demographic profile of our sample is consistent with institutional data in terms of prior experiences and company size.

Table 2. Participant background information.

Pseudonym	Company Size	Industry	Prior Experience	With Current Employer?
Eric	Large	Aerospace	Co-op	No
Jimmy	Large	Aerospace	Co-op	No
John	Large	Manufacturing/Maintenance	Internship	Yes
Sheryl	Medium	Regulations and Patents	Internship	No
Doc	Small	Consulting	None	N/A
Bonnie	Medium	Construction Management	Internship	Yes
George	Large	Manufacturing	Co-op	Yes
Jeff	Large	Nuclear	None	N/A
Eddie	Large	HVAC	Co-op	No
Kurt	Medium	Maintenance Engineering	Internship	Yes
Carrie	Large	Automotive/Industrial	Co-op	Yes
David	Large	Aerospace	Internship	Yes

Table 3. Participant demographic information.

Race/Ethnicity	Male	Female	No. of Participants
Non-Hispanic White	6	1	7
Non-White	3	2	5
Totals	9	3	12

Each case includes two forms of data: reflective journal prompts and semi-structured interviews. Weekly journal prompts probed participants for significant challenges, accomplishments, and learning events. The follow-up interviews further explored and expanded on the journal responses. We focused on the first twelve weeks for two reasons. First, to keep the research scope manageable, we selected a time period that enabled deep exploration without overburdening either participants or researchers. Second, our pilot study suggested that the first 12 weeks of work represented a period in which new and unfamiliar challenges were both magnified and readily visible for participants.[37]

Reflective journaling

Data collection used reflective journaling prompts adapted from Wallin et al. and informed by a pilot study.[38] Each week, for the first twelve weeks of work, Lutz emailed each participant a set of questions probing one of three things: 1) biggest challenge, 2) most important thing learned or realized, or 3) most significant accomplishment. The prompt also included questions to elicit details about the event. The questions varied slightly by focus (challenge, learning, accomplishment), but always used the following structure:

(1) What was your biggest challenge [accomplishment, learning] this week?
(2) What made it so challenging?
(3) How did you approach this challenge?
(4) Did anyone else play a role or help you with this challenge?
(5) What would you do differently next time?
(6) How do you see this relating to your undergraduate experiences?

Because participants were recruited before graduation, the researchers used university email accounts to collect the reflective journals. In compliance with the University IRB, reflective journal prompts were sent to participants' university email accounts, and participants responded in the body of the reply email. Because the email correspondence is considered research data, all reflections are considered exempt from FOIA requests to further protect confidentiality. Follow-up interviews were conducted after work hours; participants did not have to discuss challenging experiences while at work.

In contrast to Beddoes' work in this issue, which explored such questions retrospectively, this work asked these questions weekly in real time.[39] This approach provided a parsimonious way to capture everyday experiences of multiple individuals without the resources required for observations or ethnographies.[40]

Follow-up interviews

Following the journals, Lutz conducted a semi-structured interview with each participant; 11 used video-conferencing and one, with a local participant, was face-to-face. The interviews resembled the *Diary: Diary-interview* method in which journal entries inform the development of semi-structured interview questions.[41] The protocol asked participants to describe their job, reflect on significant challenges, and elaborate on particular journal entries. These interviews helped triangulate the journaling data and enabled deeper exploration of workplace learning.

Analysis

The five social and cultural dimensions of organizational socialization described by Chao et al. formed the initial codebook. While Chao et al. do not formally define each dimension, they do offer rich descriptions and list associated survey items. Synthesizing the descriptions and items, we developed *a priori* definitions that were then refined during coding to more accurately capture our participants' experiences; Table 4 provides the final operationalized codebook.

We made two modifications to sharpen our analysis. First, in order to focus on the social and cultural aspects of learning, we bracketed *Performance Proficiency* from the present analysis; a detailed account of this learning appears in work by Lutz.[42] Second, we changed the code *History* to *Traditions* because although the history of the organization is part of traditions, our participants' experiences included more than knowledge of historical information; even the initial work by Chao et al. describes history in broader terms than the word suggests.

Positionality, credibility, and trustworthiness

The authors have different levels of experience with the engineering work practices explored in the manuscript. Lutz has worked primarily in academia, and his experiences and training have led him to develop expertise in qualitative methods, including reflective journaling and interviewing. Challenges faced during his own school-to-work transition contributed to the broader motivation to more deeply probe this critical period. Paretti has held both industry and academic positions, including work as an engineer for a large chemical company and work in small software companies. She is an expert in qualitative and interpretive research methods.

To support trustworthiness, we implemented data triangulation, member checking, and peer debriefing and review.[43] To triangulate the data, we collected weekly written reflective journals and subsequent oral semi-structured interviews that helped participants clarify and/or elaborate on journal entries. Informal member checking occurred during journaling

Table 4. Operationalized workplace learning content codebook

Code	Operational Definition
People	Learning how to form relationships and navigate social networks
Politics	Learning the internal, sometimes tacit, norms of the organization in terms of power structures and influence
Traditions (History)	Learning to engage with the local culture of the work group and the stories, rituals, norms, and history
Goals and Values	Learning about the mission of an organization and how one represents it
Language	Learning the specific jargon and slang needed to communicate across the organization and with different organizational members

as Lutz replied to participant emails as needed to ask for detail or clarification. Formally, during week 7, Lutz provided each participant with an interpretive summary of their first six weeks of entries and invited modifications or corrections. The follow-up interviews provided a final informal member check by following up on selected journal entries.

At the data analysis stage, Lutz performed intercoder reliability checks with three different researchers. First, after developing *a priori* definitions, Lutz coded all interviews and journal reflections; Paretti then reviewed the definitions and coded segments for conceptual clarity and consistency, negotiating definitions to consensus. Second, selected transcripts were coded by two different researchers outside the research team. Lutz worked with these two researchers to review the coded transcripts together, discuss points of agreement and divergence, and negotiate discrepancies to consensus.

Limitations

Our results should be considered in light of relevant limitations. First, while 12 participants is an acceptable size for an exploratory multi-case study, the sample is not designed to be generalizable. All participants were mechanical engineering students from a single university. Further, while engineering graduates work in a range of public- and private-sector jobs, our participants were all employed in relatively large, for-profit organizations. This commercial context shapes the ways engineers interact with organizational culture, and we recommend that future researchers examine graduates in a broader range of setttings. However, according to national data, 70% of all scientists and engineers are employed in industry, with 52% in the for-profit sector (60% of those holding only bachelor's degrees) and an additional 6% are self-employed or employed in unincorporated businesses; 11% are in government and 19% in education.[44] With respect to the sample, post-graduation survey data from university from which students were recruited indicates that of those reporting employers, 80% reported employment in the for-profit sector and 20% reported government employment (predominantly in defense). Findings may be transferable to other mechanical engineering programs at comprehensive land grant institutions with similar employment profiles.

Second, our participants did not necessarily struggle in ways often described in prior research. While many studies describe newcomers as underprepared, our participants generally navigated the transition smoothly, albeit with challenges noted below. This smoothness could be related to recruitment, which occurred approximately three months before graduation; students without job offers were ineligible.[45] Further, many of our participants had previous workplace experience from co-op programs or internships, which may have provided cultural or social capital that facilitated their transition. Our participants thus may be higher achieving and better prepared for the transition than those whose employment was in flux at recruitment. Interestingly, Jesiek et al. (this issue) also note how some participants experienced what appears to be a relatively smooth transition, though they do not necessarily speculate on the reasons why.[46]

Third, the journal prompts asked participants to describe a single event each week. Given the rapid nature of learning during the school-to-work transition, participants likely experienced more than one significant event each week, but reported on only one. Moreover, the journal prompts were themselves an intervention. Because we asked participants to reflect on their experiences weekly, which they might not have done otherwise, we potentially influenced their transition. Given that reflection is generally beneficial for personal and professional development, the process likely enhanced participants' experiences and helped them learn from their reflection (a point noted in several follow up interviews).

Results

The following sections illustrate the social and cultural dimensions of learning that new engineers in this study described and highlight the ways in which these dimensions delineate contextual differences between school and work. A detailed discussion of their technical learning is available in Lutz (2017).[47]

Organizational Goals and Values

At the broadest level, participants learned new *Organizational Goals and Values* as they came to understand the motivations and norms of their new organization. Sometimes such learning resulted in feelings of belonging, commitment, and confidence in one's ability to represent the organization; at other times it led to an examination of the alignment between organizational and personal values. For example, Eddie described how an organizational training program helped him understand the *Organizational Values* that inform personnel decisions and encourage company loyalty. His language addresses the company's 'investment' in him and his responsibility to provide a return on that investment.

> I'm sort of at the beginning of a possible 40-year journey with this company. The company expects us to be great employees and leaders. The company has already invested a lot of time and money into my career, and I am expected to 'pay them back', in a way, by climbing the ladder towards a leadership position within the company. [Eddie, Week 4]

Eddie sees himself at the beginning of a long 'journey' and notes how the resources the organization has invested instill a sense of loyalty reflected in expectations of a long career arc. While Eddie's perceptions may appear naïve given the number of job changes today's employees experience, they still capture his understanding of espoused organizational values that shape his current work. Alumni pilgrimages to football games and contributions to annual campaigns notwithstanding, the relationship Eddie is building with his company as he takes on the organization's goals differ from the typical student's relationship to school, where the key goal is to obtain a degree and move on. Certainly universities seek to engage incoming students in university life (and build alumni loyalty), but where schools focus on what they can do for their students, corporate goals typically reverse that, as reflected in Eddie's understanding of his responsibility to 'pay back' what the company invested in him. University goals and values center on the ways in which the organization provides a return on students' investment (i.e. tuition).[48] The contrast offers one example of how organizational orientation might lead to an apparent skills gaps with respect to functioning in different types of organizations. Notably, Eddie seems to accept at face value the notion of a long-term 'investment,' which runs counter to the contemporary workplace.[49] In contrast to previous generations, most engineers today do not stay with one organization throughout their career, and Eddie's acceptance of that idea could indicate lack of preparation for navigating modern engineering labor markets.

Learning organizational goals and values can also surface tensions between organizational and personal values, as in Doc's case. As a regulatory compliance consultant, Doc produced a solution for a client that was more expensive than paying the noncompliance fines. He noted one week that the most important thing he learned was that 'in industry […] money moves mountains. Money can change priorities, clients, and even personal relationships.' He considered this value problematic, explaining that 'if money is the overall criteria to make a decision, ethics get forgotten.' During the follow-up interview, Doc expanded on this situation.

> [T]hey don't talk about ethics [in undergraduate engineering] and now and I can see even in my job, like there's a lot of moments. I think [Employer] has really good values where there's a really like a gray area where like, okay, we could be [within] the law […] but not really. And then being like [Employer] like really makes sure we're [with]in the law and with no shady stuff. But it's so easy to like go the other way. And nobody will know. It's just easy. [Laughing] […] So [clients] always think of, like, okay, […] what would happen if I just don't follow the law, what would be the fine? Because sometimes the fine is cheaper than doing all the processes it takes. So it's like we have to tell them, 'Well. you have to do it […] even though it's cheaper [to pay the fine and remain non-compliant].' Again, metrics beat rational[ity] and morality most of the times. So like if companies want to make money, they tell you like 'Hey the fine is going to be $100,000 but you're going to spend $250,000 to solve it'; they are going to be like, 'Just give me the fine and I will deal with it.' So it's a lot of like a money against values, I don't think they teach it but it's important to emphasize to younger people to be careful. [Doc, Follow-up interview]

Doc struggled to reconcile his personal ethical values with his ability to contribute to his organization's goals in ways that are far less common in school contexts, particularly for undergraduates.[50] He uses the word 'metrics' to refer to organizational decision-making to maximize monetary gain, and contrasts those criteria with 'morality' and 'values.' Although undergraduates make ethical decisions (e.g. around cheating or plagiarism), those decisions are typically about conflicting internal values (honesty versus grades) rather than the conflicts between personal and organizational values our participants struggled to navigate.[51] While it is unlikely that ethics were 'not discussed' during Doc's undergraduate experience (ethical decision making is a required outcome under ABET),[52] the range of school contexts in which ethical conflicts arose seemingly left him ill-prepared to navigate misalignments between his own ethical stances and those of his organization. Tensions between personal values and organizational goals are also highlighted by Gewirtz and Paretti (this issue), where competing value systems result in confusion about how to spend one's time.[53] Conflicts between personal and organizational values may be part of students' decisions to transfer out of engineering as they experience misalignments between their own values and the culture of many engineering programs; but such misalignments might not be experienced as 'ethical' in nature.[54]

Traditions

Within broad organizational values, participants also learned the traditions and history of their localized work group. In contrast to *Organizational Goals and Values*, *Traditions* describes learning linked to everyday practice in a local work group, including the history of prior work as well as local customs and ways of working and interacting. Some participants engaged in learning related to the historical practices of their work group. During week 3, for example, Eddie noted a challenge surrounding the context of his current project:

> [Biggest challenge?] My company is over 100 years old and they have a lot of history dealing with the kinds of problems I'm working on now. I have spent all week trying to assess the situation and understand the scope of the problem.
>
> [What made it so challenging?] The first hurdle is that the person who knows the most about my assigned project is on vacation until Monday, and I'll be out next Monday-Friday for training. Not much will get done over that time. Other obstacles include tracing through old email chains, trying to remember or figure out who said what about what and when they said it. My manager is on vacation and isn't available to approve some software that I need to understand the history of the problem. Figuring out who could help me was difficult. [Eddie, Week 3]

In this case, part of performing the job effectively entailed learning the history of the problem. Doing so required research related to the context of the problem, including legacy documentation and the work of employees previously assigned to the project. Traditions were embedded in email chains and knowledge accumulated by coworkers, rather than in a textbook.

Traditions also involve learning specific customs or modes of practice that are not necessarily codified in documentation but rather embedded in forms of practice handed down within the organization. In the following example, Eric describes learning what he calls 'tribal knowledge,' or ways of working that have developed over time through the experiences of different employees (in this case, mechanics).

> So basically knowledge that is handed down from mechanic to mechanic that isn't captured in the documentation. So if the document says 'install this bolt' and the mechanic is like 'here's a better way to do it' or 'here is an easier way to do it or a more effective way to do it' and whatever that part was is just from experience or from somebody else who told that mechanic as opposed to the instructions saying 'here's the easy way to do it.'. [Eric, Follow-up Interview]

Such examples highlight ways that working engineers learn the local traditions needed to do their jobs through company archives, key informants, observations, and related practices. This kind of work-related research differs from the ways students conduct background research at school. Research at school is a relatively uniform process of acquiring explicitly codified knowledge for learning, while research at work involves acquiring knowledge of relevant social and cultural contexts and idiosyncratic – often tacit – practices needed to make progress on specific projects. Moreover, the pathways that students follow at school are often narrow and predictable – faculty members, teaching assistants, students previously enrolled in a course, internet sites with homework solutions (though notably, these pathways are not equally transparent to all students).[55] Even the process of learning about specific instructors is simplified through sites like RateMyProfessor and group-maintained internet archives of past assignments. Information pathways at work are typically more varied and localized, with no designated 'TA' assigned to support learning, no solution manuals valid across all settings, no web site for accessing peers' review of supervisors. These differences shift how individuals interact with information and affect the way new engineers learn local traditions. Thus while student learning related to traditions might manifest in background research for a particular project or class, the fixed-term structure of school environments frames such research as a specific educational task (e.g. a review of literature for a capstone project) and is less instrumental in understanding broader contexts of an organization or work group. Understanding work tasks here means unpacking local history and traditions, not following a generalized pattern.

People

As the previous discussion of *Traditions* suggests, *People* form a critical component of social and cultural learning at work, which typically requires cultivating productive, collegial relationships and forming a supportive network. For example, when discussing ways to ease the school-to-work transition, John offers the following advice.

> Just to be open to it [working with other people] you know? And be I guess open-minded to the fact that people do different things different ways, and anyone can teach you stuff. […] I just learn different things from all the people I interact with. Sometimes it's how to communicate better or just about like a specific system in the plant or something like that. Everyone has something to offer. [John, Follow-up interview]

As John's comments suggest, the interpersonal networks and the opportunities to learn at work move well beyond the more structured relationships of school. Engineering courses in particular tend to be built on a banking model of education, where knowledge resides in the teacher and is given out to students; students do form supportive networks with others in their class or a year or two ahead, but the nature of those relationships is well-established across sixteen years of schooling. But at work, as John notes, these clear roles dissolve and 'anyone' can be a source of learning.

This interpersonal learning is complicated further as new engineers move from a space where their primary goal is acquiring knowledge (or passing classes) to being part of a network centered on corporate (profitability) goals, in which they often mediate among different colleagues from a range of organizational sectors. Students certainly cultivate networks at school,[56] but those networks often serve individual goals around learning and earning a degree, and they are not equally accessible to or accessed by all students; students can often still 'earn As' by working alone. At work, these networks and relationships are essential in completing projects, functioning effectively, and advancing professionally.

For example, in a journal entry, George described a challenging exchange with an 'extremely frustrated' technician whom he was supervising. During the exchange, the technician began 'bad mouthing the work of the programmer that was causing him to have issues the whole day with the machinery.' George's job, at the interface between programmers and shop floor technicians, required him to to work across these boundaries, even as the technicians and programmers had different perspectives on the work and struggled to value one another's contributions. By 'listening to all the issues [his] technician had and being the middleman to let the machine programmer know what he needed to fix,' George acted as a broker between two individuals and contributed to a productive final solution – a role students rarely play in the structured context of undergraduate courses.[57] Participants noted the role of others in their learning, and knowing people throughout their organization was key in facilitating such learning.

Language

Learning about people moves beyond building these networks to include effectively learning a new *Language*. *Language* can include organization-specific jargon, abbreviations, and discursive practices, but for our participants it also included learning to communicate regularly with a significantly expanded range of individuals. For example, George, working for a company headquartered in Asia, described challenges related to communicating with coworkers overseas. In a teleconference he led in his third week of work, he struggled because of the differences in spoken English patterns and noted that he 'had to talk differently than what I am accustomed to.' However, in week 12, he described leading another such meeting after learning from his prior experiences and from observing his supervisors facilitate these calls. He took notes beforehand, developed an agenda, and made sure to speak clearly using language understandable to both groups. That is, George learned to adjust his communicative strategies to create mutual understanding and support a more organized approach to sharing information.

Language-related learning also includes regularly communicating with organizational colleagues unfamiliar with engineering jargon. Jeff, in his initial training, learned such considerations with respect to writing:

> Right so I remember we had one day where we talked about writing style. And it kind of surprised me, they want us to write at, I think it was an eighth grade level or lower. Yeah. Because otherwise there's a lot of people there that would you know not necessarily understand it but wouldn't follow it I guess. But and you know to keep sentences short and to the point. Just like working on something for people that I hadn't expected to incorporate into my work before I guess. So kind of what I was expecting out of school from what they told me it was going to be like it was it would be designing and maybe making presentations for someone that wasn't engineering but was most definitely a college grad. Like a business major or something like that. [Jeff, Follow-up interview]

Jeff's supervisors focused on helping him learn to speak and write in ways that would be accessible to those who needed his information to make decisions. His comments highlight important contextual gaps between school and work. At school, as Jeff's comments indicate, students interact primarily with other college students, and, as they move through curricula, increasingly with students in their majors who speak the same language. In contrast, at work, engineers must communicate with colleagues not only from different disciplines, but with different educational backgrounds, responsibilities, and needs. Learning language at work is not only about acquiring organizational jargon, but about expanding the range of audiences well beyond those encountered in school contexts.

Politics

Finally, to return to a system level view, engaging with people also means learning *Politics*, including both the resources and tacit power structures that, while perhaps less visible, impact organizational practice. For instance, Jimmy noted the importance of developing relationships with those above him in the organizational hierarchy.

> The connections I make [will be valuable], because all the people I'm working with are very, pretty high up in management. And that's pretty cool because these guys know my name, like […] my cube is literally in the center of where all the management guys sit. So I know all of them and I know all them really well, and like the Top Dog in my office, he's like the VP of the division, he just comes by my cube, 'hey what are you working on?' And I tell him and he's like 'Wow. That's awesome, and you're doing great work.' […] I definitely don't think they're going to forget me. Like I'm not just going to go away and they're going to forget about me and I'm just going to get thrown into the grinder. [Jimmy, Follow-up interview]

Jimmy links being visible to those with organizational power to being remembered and, implicitly, moving up rather than getting 'thrown into the grinder' to be forgotten or passed over. Similar findings are echoed in Gewirtz and Paretti's detailed narrative analysis of Catherine, a recent engineering graduate who works to become an 'important asset' within her organization (this issue).[58] Such social and navigational capital is also part of schooling, but the nominal goal of school is to ensure that all students achieve particular learning outcomes competencies. [59] To that end, engineering programs increasingly offer support structures and services to help expand marginalized students' access to such capital.[60] These programs intentionally facilitate access to critical resources and individuals, but such opportunities do not always exist within commercial organizations. Organizations are designed to ensure that the company, not the individual, succeeds. As a result, while they may provide formal training or mentoring, they rarely offer the kinds of extended support services that universities provide. Such school structures include not only faculty and teaching assistants who are paid to provide instruction, answer questions, and support learning, but also tutoring centers, academic success programs, residence hall programming, and more. Without such formalized systems or programs to explicate and provide access to power structures, individuals must take it upon themselves to identify and navigate organizational politics.

Lack of access to these political structures, moreover, can create barriers to success, as in a case Kurt described that involved a power struggle with shop workers over a maintenance order. As the primary engineer assigned to the project, Kurt made a recommendation that the mechanics disagreed with; ultimately he had to solicit help from a more experienced engineering technician to resolve the conflict. In reflecting on the challenge, Kurt explicitly identified the power structures in play: 'Being new I don't have much pull, so having someone that would tell them to fix it would have been much better.' This experience helped Kurt better understand how to leverage the 'pull' of others to accomplish work and resolve conflicts. Kurt's conclusions were echoed by several other participants who recognized their precariousness as newcomers who could easily be fired and their corresponding lack of 'pull' to move work forward.

At school, both the power structures (e.g. teachers, administrators) and the resources (e.g. a dean of students, academic support centers) are often more clearly delineated and follow patterns that students learn across years of schooling, though as noted, these are not equally visible and accessible to all students. In contrast, work power structures may be more complex and less readily accessible for newcomers whose lack of experience limits their influence. The lack of power itself may be a new experience for many new engineers, particularly high-achieving students, and may exacerbate gaps in social and navigational capital for minoritized graduates.

Summary of Results

Our findings highlight how the context shift from school to work involves learning along multiple social and cultural dimensions. Our results illustrate the differences in both system-level structures associated with learning organizational goals and values as well as politics, and local-level practices associated with learning traditions, acquiring language, and building interpersonal networks, as experienced by graduating engineers negotiating this transition. The organizational socialization framework proposed by Chao et al. provides a useful mechanism to operationalize these contextual differences by delineating critical areas of newcoming learning.

Discussion

The social and cultural dimensions of new engineers' organizational learning complicate simplified accounts of the 'skills gap' among new engineers by attending to the processes of learning about and adapting to new organizational cultures. While students might implicitly grapple with social and cultural learning at school, their extended experience in academic contexts often renders such learning invisible. Table 5 summarizes the current findings related to learning in engineering organizations and contrasts them to their academic analogs.

These findings highlight contextual differences and point to learning at organizational, work group, and interpersonal levels.

Learning at the organizational level

At the broadest level, our findings illuminate learning related to the organization graduates enter. Such learning includes cultural norms, rituals, and customs that are reified through a range of policies, practices, and artifacts.[61] Such learning is most clearly demonstrated by participant discussions of *Organizational Goals and Values*, which often entailed what Kunda (2006) has termed 'role embracing' in which organizational members come to recognize and align themselves with the cultural values within an organization.[62] Some participants used the phrase 'drinking the Kool-Aid' to describe the internalization of cultural norms. In other cases, learning about organizational values resulted in internal conflicts with their own values that participants struggled to resolve. In learning about the goals and values of their organizations, these newcomers had to reorient their work – technical and social – not toward decontextualized learning but toward the specific market and economic ends and organizational values of their employer.

Shifts at the organizational level also include learning about *Politics* as participants accessed and navigated organizational hierarchies and power structures, foregrounding the importance of social, cultural, and navigational capital. In some cases, this capital helped give participants visibility and access to organizational power that was difficult to directly observe, but still had consequences for their interactions and career trajectories. At other

Table 5. Dimensions of the context shift in organizational learning across school and work.

Social and Cultural Dimension	At School	At Work
People	Teamwork among engineering studentsLeadership of other engineers	NetworkingBrokering/managing Relationships among diverse stakeholders
Organizational Goals and Values	Obtain a degree from organizationTeam Spirit	Give back to organization (return on investment)Person-Organization fit and alignment
Traditions (History)	Explicit contentBackground research	Implicit norms for behaviorUnderstanding context of existing projects
Language	Giving presentationsCommunication with other engineers	Talking with diverse stakeholdersEnsuring mutual understanding
Politics	Co-curricular organizations and societies	Informal power structuresAccruing cultural/social capital

times, lack of capital hindered participants' ability to accomplish tasks. In either case, interactions with political structures were sites of learning that reflect critical differences across school and work. These kinds of power structures, both visible and invisible, are illustrated in detail by Gewirtz and Paretti (this issue), who demonstrate the ways in which new engineers both work to fit within and resist the power dynamics within their organizations.[63] Political structures also influence learning at school, but are potentially less visible to students, especially those from minoritized groups and/or those who might have less social and cultural capital.[64] Although cocurricular spaces (e.g. clubs, professional societies) might offer models for the ways in which power influences organizational decisions and functions, not all students participate in such activities and therefore may not have experience navigating these structures. Understanding organizational politics can help individuals identify and navigate power structures, but neither power structures nor opportunitines to learn about them are always explicit or available to engineering students.

Learning at the work group level

Our work also highlights contextual differences at the local work group level. While the organization shapes macro-scale values and expectations, the local work group is the context in which individuals learn job-related tasks and acquire an understanding of social norms.[65] Learning at this level entails coming to know how work tasks are done and why they are done that way. For our participants, learning the *Traditions* of an organization involved picking up the tacit cultural knowledge that was not explicated organizationally but was nonetheless reified in members' modes of working and interacting. Learning along these dimensions involved understanding the history of problems and practices, accepted ways of accomplishing tasks, *a priori* approaches for interacting within particular groups, and other unspoken norms.

Co- and extra-curricular school organizations might resemble these kinds of local work groups, but such organizations are not necessary to the core purpose of obtaining a degree and are therefore not positioned as essential to effective functioning at school (though they are certainly useful). Students who join long-running competition teams (e.g. Formula SAE, Baja SAE) may also encounter established local groups, but such teams constitute only a small part of the educational environment, and regular turnover of team members as well as changing competition rules create ongoing disruptions. Certainly organizations such as fraternities and sororities have established histories and traditions that persist over time, as do more local student groups. But high membership turnover as large numbers of students both join and graduate each year makes engagement with these histories somewhat different than a single new engineer entering an established company. Moreover, within the engineering school environment, dominated by formal classes, students do not routinely enter into existing work groups. While departments and degree programs have histories and practices that students might need to learn, these practices are often reified through formalized policies and documentation.[66] In classes, teams and study groups are more likely to be emergent, and thus lack the extended tacit histories and habits of local work groups in engineering organizations. Similarly, students may acquire knowledge about a given instructor or course from previous students (e.g. through past exams or assignments), but even then, only the instructor remains the same while the 'work group' of the class reforms each semester.

Similarly, *People* were central to work-group learning as participants developed productive relationships within their teams that enabled them to accomplish work. Participants described how social relationships helped facilitate their learning, but their experiences illustrate the complexity of establishing these relationships and the need for both awareness (who has what information) and intentional effort. Our findings echo work by Korte, who demonstrated the importance of social exchanges in newcomers' organizational learning.[67] In contrast, at school, the working relationships students need are often explicitly defined: faculty and teaching assistants provide learning support; labs and machine shops support student projects and have established protocols that allow them to serve high numbers of continuously changing students. Moreover, these relationships may often be only for a single term, in contrast to organizational units an engineer may work with over years. Similarly, student teams are typically newly formed in each course, with each team member on parallel footing, sometimes with instructions related to effective teamwork, project management, leadership, and interpersonal skills.[68] This continual formation of new teams of peers within environments designed to support learning requires a different approach to relationship-building than entering into an established work group and connecting with a wide range of different organizational members (e.g. marketing, finance, technicians). Indeed, as Beddoes (this issue) notes, these workplace interactions are critical and can both contribute to and undermine an individual's ability to cultivate meaningful and productive workplace relationships and support structures for recent graduates.[69]

Learning at the interpersonal level

Finally, new engineers encounter contextual differences at the interpersonal level. Interpersonal interactions are essential to help new engineers gain specific knowledge, accomplish work, and shape their careers.[70] Here, the learning along both the *People* and *Language* dimensions reflects contextual shifts from school to work. Where interpersonal engagement at school is most often with peers of similar age and educational background, or with individuals in familiar roles (teacher), interpersonal engagement at work encompasses a much broader range of interactions that complicate simple transfer of skills, even skills one is 'good' at. For example, in learning related to *People*, George needed to learn how to broker interactions between computer programmers and shop technicians. Though these two groups did not get along, their work was critically connected. In this case, George developed listening skills and leveraged existing relationships to overcome project delays. Even when school prepares students with relevant skills, students rarely have extended opportunities to deploy them in the same way.

Similarly, even when students learn professional communication, they rarely have the opportunity to communicate in the ways suggested by the *Langauge* dimension of learning for our participants. Where Chao et al. centered *Language* on learning organization-specific terms and jargon, our operationalized definition expands it to include discursive practices within the organization and interpersonal communication strategies. Participants noted the importance of modifying the way they spoke with colleagues to reach shared understanding and advance work projects. Their experiences stand in contrast to communication at school, where individuals talk primarily with other engineering students and instructors well versed in the jargon of the project or course. The role of language is also highlighted by Jesiek et al. (this issue),[71] where participants describe the importance of communication with different organizational members (e.g. technicians, managers) as engineers engage in boundary-spanning activities. Further, communication at school often focuses on technical writing or presentations, usually directed at other engineers (professors or peers).[72] Even when students create reports and presentations for a diverse audience, researchers have noted the limitations inherent in creating authentic environments for such communication.[73]

Conclusion

As our participants engaged in social and cultural learning, they experienced significant contextual shifts in how they related to individuals, local work groups, and organizations. Such contextual shifts, as situated learning suggests, mean that even when students have learned salient technical and professional skills in school, they must learn to deploy and adapt those skills in unfamiliar ways as they transition to work.[74] This learning, in turn, suggests that the so-called competency gaps might be more appropriately framed as context gaps. Such framing, embodied in the social and cultural learning of our participants, shifts discussions about the relationship between school and work, reframing what it means to 'be prepared' for engineering practice and how educators and industries can help students navigate the transition.

For educators, some of these social and cultural dimensions might be harder to teach for than others. While learning related to *People* might occur in project-based contexts, dimensions such as *Politics* or *Organizational Goals and Values* might be more challenging, especially within technical engineering science courses. To do so, faculty might leverage concepts from the hidden curriculum, which centers and problematizes aspects of learning and cultural values that are often taken for granted in academic contexts. [75] The hidden curriculum interrogates taken-for-granted choices about content coverage in ways that explicate the values inherent within a given educational context. For instance, decisions to focus on exclusively technical content in engineering science classes often sends the implicit (and sometimes explicit) message that social or cultural aspects of engineering (e.g. ethical reasoning) are not central to engineering work. These messages in turn shape student beliefs about what engineering is and what kinds of problems engineers should be concerned with. Instructors can talk with students about what material is left out, why, and what that omission suggests about the values of the institution and profession. Such conversations can help students recognize the role of *Traditions* in curricular decisions and the importance of *Organizational Goals and Values* in assessment and accreditation. By explicating the role of social and cultural learning within their educational contexts, students might more readily recognize and learn to adapt to diverse workplace contexts.

For researchers, our findings raise questions about the role of engineers and their agency in shaping the culture of engineering workplaces. Engineers and engineering educators need to recognize the ways they can shape the profession because no organization's goals, values, and practices are inevitable or static. Rather, organizational practices are continually constructed and reified by its members.[76] This dynamic suggests that new engineers can themselves shape social and cultural aspects of their organizations. For example, as Doc noted, decisions may be driven by environmental interests, but also by profit. Such issues result from collective choices made by individuals and groups within an organization. At the same time, as Gewirtz and Paretti note (this issue) that influence is constrained by the existing structures, and new engineers are not implicitly or explicitly heroes in a narrative of corporate transformation.[77]

While most engineering curricula focus on technical content and analytical problem solving, our findings demonstrate that newcomers' organizational learning is simultaneously social and cultural. Our participants described significant learning in ways that illuminate these components and point to contrasts across professional and academic contexts. As these engineers learned to perform their jobs, they also learned new organizational cultures, languages, value systems, and ways of working and interacting. This learning provided a foundation from which to gain competence and acceptance.

To address the context gap, educators and companies should make visible the social and cultural dimensions of engineering work and of the institutions in which this work happens. By making such dimensions visible, educators and professionals can better articulate the interconnectedness of the social, cultural, and technical elements of engineering practice; help engineers navigate learning at multiple organizational levels; and leverage these contextual shifts to empower engineers to engage with the full range of learning needed in the transition from school to work.

Notes

1. Mann, *A Study of Engineering Education*; Grinter, "Report on Evaluation of Engineering Education"; NAE, *Educating the Engineer of 2020*; American Society of Mechanical Engineers Center for Education, "Vision 2030."
2. Paretti, "Teaching Communication in Capstone Design"; Jonassen, "Engineers as Problem Solvers"; Buch, "Ideas of Holistic Engineering Meet Engineering Work Practices."
3. Paretti et al., "Process Matter(s)"
4. Jonassen, Strobel, and Lee, "Everyday Problem Solving in Engineering.."
5. Rooney et al., "Using Practice Theory to Investigate Professional Engineers' Workplace Learning"; Reich et al., "Engineers' Professional Learning"
6. Bucciarelli, "An Ethnographic Perspective on Engineering Design."
7. Anderson, Courter, McGlamery, Nathans-Kelly, & Nicometo, "Understanding Engineering Work and Identity."
8. Trevelyan, "Reconstructing Engineering from Practice."
9. Trevelyan, *The Making of an Expert Engineer*.
10. Lang et al., "Industry Expectations of New Engineers"; Rugarcia et al., "The Future of Engineering Education I."
11. Jonassen, "Engineers as Problem Solvers."
12. Riley, "Engineering and Social Justice"; Faulkner, "Dualisms, Hierarchies and Gender in Engineering."
13. Faulkner, "Dualisms, Hierarchies and Gender in Engineering"; Faulkner, "Nuts and Bolts and People'."
14. Kotys-Schwartz, Besterfield-Sacre, and Shuman, "Informal Learning in Engineering Education"; Polmear, Chau, and Simmons, "Ethics as an Outcome of Out-of-Class Engagement across Diverse Groups of Engineering Students"; Simmons, Polmear, and Lord, "Impactful for Whom?"; Stevens et al., "Becoming an Engineer."
15. Cairns, "Learning in the Workplace: Communities of Practice and Beyond."
16. Margaret, *The SAGE Handbook of Workplace Learning*.
17. Korte, Brunhaver, and Sheppard, "(Mis) Interpretations of Organizational Socialization," 192.
18. Trevelyan, "Are We Accidentally Misleading Students about Engineering Practice?"
19. Korte, Brunhaver, and Sheppard, "(Mis) Interpretations of Organizational Socialization."
20. Clark et al., "Academic Pathways Study"; Sheppard et al., "Engineering Pathways Study"; Brunhaver et al., "Professional Engineering Pathways Study"

21. Korte, Sheppard, and Jordan, "A Qualitative Study of the Early Work Experiences of Recent Graduates in Engineering."
22. Sheppard et al., "Work in Progress—Engineering Pathways Study"
23. Martin et al., "Engineering Graduates' Perceptions of How Well They Were Prepared for Work in Industry."
24. Ford et al., "Transitioning from Capstone Design Courses to Workplaces"; Gewirtz et al., "New Engineers' First Three Months"; Howe et al., "Women's Experiences in the Transition from Capstone Design Courses to Engineering Workplaces."
25. Stevens, Johri, and O'Connor, "Professional Engineering Work"; Bauer et al., "Newcomer Adjustment during Organizational Socialization."
26. American Society of Mechanical Engineers Center for Education, "Vision 2030"; Clough, "The Engineer of 2020"; Trevelyan, "Reconstructing Engineering from Practice."
27. Brunhaver et al., "Bridging the Gaps between Engineering Education and Practice"; Wisniewski, "Novice Engineers and Project Management Communication in the Workplace."
28. See, for example, Hora et al.'s critique of universities as site of job training. They argue in part that narratives about skills gaps allow corporations to shift the responsibility and expense of employee development onto universities. Within engineering, Walther and Radcliffe's nuanced critique highlights goal conflicts and differences in definitions of competence that generate tension between universities and workplaces.
29. Stevens, Johri, and O'Connor, "Professional Engineering Work"; Bauer et al., "Newcomer Adjustment during Organizational Socialization"; Hora, *Beyond the Skills Gap*; Walther and Radcliffe, "The Competence Dilemma in Engineering Education."
30. Jesiek, Buswell, and Nittala, "Performing at the Boundaries"
31. e.g., Trevelyan, "Reconstructing Engineering from Practice."; Anderson et al., "Understanding Engineering Work and Identity.", Trevelyan, *The Making of an Expert Engineer*.
32. Paretti et al., "Board# 116: Collaborative Research: From School to Work"; Lutz and Paretti, "Into the Workplace"; Lutz and Paretti, "Exploring School-to-Work Transitions through Reflective Journaling."
33. Beddoes, "Examining Privilege in Engineerig Socialization Through the Stories of Newcomers."
34. Chao, O'Leary-Kelly, Wolf, Klein, & Gardner, "Organizational Socialization."
35. Chao et al., "Organizational Socialization"; Allen et al., "Taking Stock of Two Relational Aspects of Organizational Life"; Kammeyer-Mueller et al., "Support, Undermining, and Newcomer Socialization"; Lu and Tjosvold, "Socialization Tactics"; Beus et al., "Adjusting to New Work Teams."
36. Lutz, "Into the Workplace."
37. Lutz and Paretti, "Into the Workplace."
38. Lutz and Paretti, "Into the Workplace"; Wallin, "From Tissue Engineering to Engineering Education Research"; Wallin and Adawi, "The Reflective Diary as a Method for the Formative Assessment of Self-Regulated Learning."
39. Beddoes, "Examining Privilege in Socialization."
40. Wieder and Zimmerman, "The Diary: Diary Interview Methods."
41. Wieder and Zimmerman, "The Diary."
42. Lutz, "Into the Workplace."
43. Rossman and Rallis, *Learning in the Field*.
44. https://www.nsf.gov/statistics/2016/nsb20161/#/report/chapter-3/s-e-workers-in-the-economy/employer-size
45. Collins, "Engineering Graduate Preparedness for the Workplace"; American Society of Mechanical Engineers Center for Education, "Vision 2030"; Clough, "The Engineer of 2020."
46. Jesiek, Buswell, and Nittala, "Performing at the Boundaries."
47. Lutz, "Into the Workplace."
48. Molesworth, Nixon, and Scullion, "Having, Being and Higher Education"; Bunce, Baird, and Jones, "The Student-as-Consumer Approach in Higher Education and Its Effects on Academic Performance."
49. Arnold, Coombs, and Gubler, "Career Anchors and Preferences for Organizational Career Management."

50. Graduate students, however, may encounter parallel ethical dilemas in their research.
51. Lutz, Canney, and Brunhaver, "'I Wish I Could Do More'."
52. https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2020-2021/
53. Gewirtz and Paretti, "Becoming After College."
54. Seymour and Hewitt, *Talking about Leaving*; Ohland et al., "Persistence, Engagement, and Migration in Engineering Programs"; Lichtenstein et al., "Retention and Persistence of Women and Minorities along the Engineering Pathway in the United States"; Stevens et al., "Becoming an Engineer."
55. Foor, Walden, and Trytten, "'I Wish That I Belonged More in This Whole Engineering Group'."
56. Weidler-Lewis, "Transformation and Stasis."
57. One exception might be capstone design courses, though even there students rarely occupy the role George describes.
58. Gewirtz and Paretti, "Becoming After College."
59. Foor, Walden, and Trytten, "'I Wish That I Belonged More in This Whole Engineering Group'"; Stevens et al., "Becoming an Engineer"; Martin, Simmons, and Yu, "The Role of Social Capital in the Experiences of Hispanic Women Engineering Majors."
60. Lee and Matusovich, "A Model of Co-Curricular Support for Undergraduate Engineering Students."
61. Wenger, *Communities of Practice*.
62. Kunda, *Engineering Culture*.
63. Gewirtz & Paretti, "Becoming After College."
64. Foor, Walden, and Trytten, "'I Wish That I Belonged More in This Whole Engineering Group'."
65. Korte, "How Newcomers Learn the Social Norms of an Organization"; Korte, "Learning How Things Work Here."
66. Friedensen, Rodriguez, and Doran, "The Making of 'Ideal'Electrical and Computer Engineers."
67. Korte, "How Newcomers Learn the Social Norms of an Organization."
68. Kumar and Hsiao, "Engineers Learn 'Soft Skills the Hard Way'"; Schuhmann, "Engineering Leadership Education."; Lingard and Barkataki, "Teaching Teamwork in Engineering and Computer Science."
69. Beddoes, "Examining Privilege in Socialization."
70. Carmeli, Brueller, and Dutton, "Learning Behaviours in the Workplace"; Wenger, *Communities of Practice*.
71. Jesiek, Buswell, and Nittala, "Performing at the Boundaries."
72. Paretti et al., "When the Teacher Is the Audience."
73. Paretti, "Teaching Communication in Capstone Design."
74. Lave and Wenger, *Situated Learning*.
75. Tonso, "'Plotting Something Dastardly'"; Redish, "Introducing Students to the Culture of Physics."
76. Wenger, "Communities of Practice."
77. Gewirtz and Paretti, "Becoming After College."

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