Social and Technical Dimensions of Engineering Identity

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Abstract

This brief paper depicts a current snapshot of an ongoing investigation that probes how students reconcile social and technical forms of identity in engineering education. While the detailed results are represented in other publications, this paper highlights the study in its current form in order to describe what will be presented at the poster session that corresponds to this paper. The outcomes of this ongoing investigation will be relevant for engineering educators who are focused on sharpening the social and technical competencies of their students. As we in engineering education seek to develop engineers that competently navigate a sociotechnical practice, this study provides a detailed snapshot of how social and technical perspectives of engineering affect the individual experience of identity development and, in turn, how an individual develops a sense of belonging and commitment to engineering.

Summary of Investigation

A growing body of scholarship has discussed how dominant cultures of engineering shape students' and professionals' understandings of social and technical dimensions of their work[4-11]. Further, engineering education research has advanced understanding of how engineering identity is formed by external, structural forces[12-15]. Yet, from a psychological perspective, we know little about how engineering students come to perceive and embody their identities as engineers, especially in relation to social and technical dimensions of these identities. Thus, we organized this study around the following research questions.

RQ0: How do students psychologically experience identity trajectories of becoming engineers?
RQ1: How do students perceive the social and technical features of engineering identity?
RQ2: How do students internally experience their identities as engineers, particularly in relation to social and technical dimensions of these identities?
RQ3: As students progress through their engineering degree programs and into engineering workplaces, how do their experiences of identity develop and change, particularly in relation social and technical dimensions of these identities?

To respond to these research questions, we have conducted two longitudinal studies using interpretative phenomenological analysis (IPA)[16]. One study focused on graduating seniors as they transitioned into the workplace, and the second study focused on first-year students transitioning to engineering degree coursework. These investigations produced robust and nuanced understanding of students' engineering identity trajectories throughout and beyond the curriculum. We are in turn using findings from these studies as an initial foundation for a thematic analysis on sophomore engineering students as they transition into their junior years.

In this conference paper we focus on two features of this study that have not yet been published. First, we explore a review of prior literature related to social and technical features of engineering practice and how these features relate to engineering identity. Second, we consider how preliminary findings from the longitudinal IPA study on first-year engineering students relate to social and technical dimensions of engineering identity.

Literature Review: Social and Technical Dimensions of Engineering Practice

What do we mean by social and technical dimensions of engineering practice and identity? To elaborate, we first consider literature that focuses on how these dimensions are realized in engineering practice. The notion that a complex social world deeply interacts with the technical world of engineers is recognized from multiple perspectives. From his ethnographic study of early career engineers, for instance, Trevelyan supports this sentiment by noting that "technical coordination," or "working with and influencing other people so they conscientiously performing some necessary work in accordance with a mutually agreed schedule" (p. 191), was identified as the most prominent skill required in his studies of engineering practice.[17] His later work characterizes engineering as a "combined human performance, in which expertise is distributed among the participants and emerges from their social interactions" (p. 176)[18] Consistent with these findings, Brunhaver et al. conclude that "[i]n addition to doing technical work, young engineers are responsible for non-technical tasks that require significant social interaction, such as managing projects and coordinating the work of other people."[19] This conclusion is supported by data from a large-scale, interview-based study of both young engineers and longitudinally tracked engineering students[19].

Additionally, Bucciarelli[7, 20], through studying early career engineers, draws upon the engineer's disciplinary knowledge of mathematics, physics, and the engineering sciences to describe his perspective of engineering practice as "the object world" (p. 5)[20]. He further depicts engineering design as a "social process" (p. 2)[20], where multiple persons navigate their disparate technical, disciplinary identities, or "object worlds" (p. 5) [20], in the course of design. In this regard, he argues that although engineers might find their identity in a technical object world, the reality of practicing design transports such engineers into a world that is highly social. Through their ethnography of household waste containers, Bovy & Vinck[8] reinforce the socio-technical reality of engineering problem solving and practice. In this study, they demonstrate in their study how "[the engineer] discovers an unexpected plurality in the world of the household, which the designer believes to be a socially homogeneous group… The introduction of a new object reveals the heterogeneity of society… [The engineer] finds that society is composed of social groups with different objectives, identities, interests, and types of behaviors" (p. 53)[8]. In other words, their study reveals how the very existence of a technical product elicits the complexity of a social world surrounding the product. Many other sociological and STS studies[9, 10, 21] corroborate the argument that seemingly technical ways of engineering thinking and doing actually elicit highly social processes.

Moreover, Downey et al. argue that engineering might be recognized as a sociotechnical practice, where "[e]ngineering problems do not solve themselves; they are always solved by people. Once people are introduced to the problem-solving situation, it takes on human as well as technical dimensions" (p. 109)[22]. Such a perspective on the human dimension might lead the engineer to sharpen her use of social elements in engineering practice (e.g., through communication, teamwork) and thoroughly consider related human and contextual dimensions when solving problems. Regarding this latter point, Adams et al. note that "[w]hen human and contextual factors are integrated into the system, the limits of prior views of 'good practice' or 'good science' are revealed and enable new ways of thinking about system performance" (p. 602)[23]. Essentially, according to these perspectives, *engineering practice* comprises an integrated form of social and technical types of problem solving.

Such a sociotechnical perspective of engineering can also be related to sociological theories of technology and society (e.g., Social Construction of Technology[24]; Affordance Theory[25]; ANT[26, 27]; Sociotechnical Imaginaries[28]). While there is considerable variety in this body of theory, together they help reveal the ways in which technical and social worlds are frequently intertwined, as well as the failure of many engineers (and non-engineers) to recognize this interconnectedness. For example, Latour points out that "[the default sociological position] has been to posit the existence of a specific sort of phenomenon variously called 'society', 'social order', 'social practice', 'social dimension', or 'social structure' . . . Once this domain had been defined, no matter how vaguely, it could then be used to . . . provide a certain type of explanation for what other domains could not account for—an appeal to 'social factors' could explain the 'social aspects' of non-social phenomenon" (p. 3)[26]. In other words, these theories challenge such a default position by recognizing the role of technology in shaping society, recognizing both the relevance of engineering work (i.e., technology) in shaping society and the ubiquitous, inseparable social "dimensions" that conversely pervade engineering and other technical work.

Literature Review: Social and Technical Dimensions of Engineering Identity

The literature in the previous section cites various studies that demonstrate the fuzzy boundary between the social and technical characteristics of engineering practice. However, as the reader might note, these studies are characterized by their external focus on engineering practice, not necessarily on how engineers *themselves* might realize and enact such social and technical dimensions. How, then, do the blurred social and technical features of engineering practice relate to social and technical features of how people *identify* as engineers? We consider this question by exploring four general frameworks that characterize social and technical ways of *being* engineers. Though these studies do not all explicitly relate to the concept of engineering identity, they are distinct from the studies of the previous section in that they focus on *ways to be an engineer* rather than on *ways of describing engineering work*.

We begin by exploring Riley's conception of an engineering stereotype. She unpacks such a stereotype by critically examining professional humor, or engineering jokes. Riley relies on such data as "jokes make important contrasts between engineering and other professions, which reveals something about common mindsets in engineering which are less common in other professions" (p. 34)[29]. Among several characteristics that she highlights, Riley (2008) claims that the stereotypical view of an engineer is one who is "too focused on technical details to relate socially or just enjoy the day" (p. 37) [29]. Additionally, she notes that a stereotypical engineer values "problem-solving abilities and a celebration that engineers can solve problems others cannot" (p. 35) [29]. She continues that "[p]art of this ability is credited to another value—exclusive technical focus" (p. 35) [29]. Riley does qualify that she is describing the content of a socially constructed stereotype rather than individual engineers. But her critical analysis renders visible a narrative that seems well-known among engineering educators, practitioners, and policymakers, inspiring such projects as the National Academy of Engineering's attempts to “change the conversation” regarding these stereotypes of engineering[30]. Riley’s documentation of such stereotypes depicts a profession that is entirely technical and exclusive of any social dimension[29].

As cited earlier, Faulkner’s critical ethnography of software engineers in the workplace reveals a complementary picture. In fact, her studies provided the framework of *social/technical dualism* (p. 764)[4]. However, Faulkner’s own fieldwork demonstrates that while engineers themselves tend to uphold this social/technical dualism as an ideal, both dimensions tend to be much more intertwined in actual engineering practice. The engineers of her study separated their work into technical dimensions that they valued as core to their identities, and social dimensions that were relegated to a more marginalized position. Trevelyan’s ethnographic studies of engineers also corroborate the notion that “[e]ngineers tend to share an identity mainly framed in terms of the solitary technical: problem-solving and design” (p. 176) [4]. He further extends Faulkner’s framework by noting that in addition to regarding social dimensions of engineering work as “mundane”, engineers also diminish the importance of certain “technical work that relies on distributed expertise, such as checking and review” (p. 176) [4]. Thus, Faulkner depicts how engineers tend to enact a dualistic categorization of social and technical dimensions of their work, where the technical receives priority.

Lagesen & Sørensen respond to Faulkner’s[4] social/technical dualism by challenging the starkness of such dualistic thinking, reporting that software engineers at three Norwegian corporations frame “communication with customers” as a highly integrated social and technical competency. Yet even though they dispute the precise form of social/technical dualism found in engineering thinking, they uphold its pervasive existence, noting that their “interviewees did distinguish between ‘social’ and ‘technical’ knowledge, but they did so in a subtle manner by accounting for knowledge about ‘social’ features in lay terms, often as personal skills, while they referred to technological competence in a professional, knowing manner. This shows how complex the enactment of the social/technical binary in engineering may be” (p. 146)[11]. Their framework demonstrates that the boundary between social and technical, as perceived by actual engineers, might be fuzzier than portrayed in earlier described frameworks.

We have reviewed three general frameworks that can be used to interpret social and technical dimensions of engineering identity. We do not suggest that these are a complete set, but these do provide explicit language to relate social and technical dimensions of engineering identity with one another (see also Williams, Figueiredo, & Trevelyan[31]). Though they vary in how strongly they divide the social and technical dimensions of engineering, all the frameworks suggest that being an engineer is primarily seen as something that is a technical activity rather than a sociotechnical one. Such demarcated frameworks of engineering identity curiously differ from the more integrated, sociotechnical picture of engineering practice that was portrayed in the previous section. And the gap between how engineering is realized as an *identity* compared to how it is enacted in *practice* is recognized in existing literature.

Indeed, a growing body of scholarship recognizes the necessity of engineers integrating their social and technical worlds for the sake of fully understanding the implications of their work as pertinent to social dimensions of engineering work. For example, Cech argues that there is a dominant view of engineering as “a ‘technical’ space where ‘social’ or ‘political’ issues…are tangential to engineers' work" (p. 67)[32]. She further argues that such beliefs are developed in the course of the undergraduate engineering curriculum. Moreover, Kilgore et al.'s study found that beginning (and especially women) students were "sensitive to important contextual factors" (p. 321)[33] and further argue that "efforts to broaden participation in engineering should consider legitimizing and fostering context-oriented approaches to engineering earlier in the curriculum" (p. 321) [33]. Many other scholars discuss this tension between the social realities of traditional engineering practice and a lack of social awareness practicing engineering courses and among engineering students and professionals[34-37].

Preliminary Findings: Social and Technical Dimensions of Engineering Identity of First-Year Engineering Students

Yet how do these frameworks of understanding social and technical become internalized in engineering students? This investigation has sought to discover the answers to this overarching questions. While we have previously written on our related studies focused on engineering graduates as they transitioned to the workplace[1-3], we now focus on emerging findings from a group of first-year engineering students that have transitioned to the core curriculum of their degree programs.

In this investigation, we finalized data collection with a group of students that we began interviewing when they were first-year engineering students. Specifically, we conducted third and final interviews with 4 (3 female; 1 male) of the 11 participants that were interviewed as first-year engineering students. Consequently, we now have 12 interviews (4 individuals interviewed 3 times apiece) to analyze as a set. We are systematically examining these interviews to find psychological themes regarding how participants experience and perceive social and technical ways of being engineers—and how they *develop* in their thinking.

Although analysis is ongoing, preliminary findings for this phase of the study are informative. First, these engineering students, upon entering their first-year of engineering education, connect engineering to a broad narrative that is deeply connected to their social experiences (e.g., becoming a civil engineer to restore infrastructure for the United States, becoming an electrical engineer to improve devices for education). While their broad motivations for entering an engineering major did not completely fade as they entered into the engineering science courses of their sophomore year, the study participants started to view engineering as more connected to the application of math and science courses. Consequently, as participants began their engineering career, they saw being an engineer as deeply connected to their own social worlds. But as they progressed in the engineering curriculum, they began to identify engineering as something that was more related to technical abilities than to a social purpose.

Second, as first-year engineering students progressed in their degree plans, the role of their families shifted. Initially, they relied greatly on their parents and siblings for social support while embarking on their engineering majors. Yet as they progressed to the sophomore year, they began to develop a network of social support among their peers that somewhat replaced the support of their families. If their primary social groups also comprised engineering students, then the study participants had new meaning in their engineering identities. Being an engineering student, to them, meant that they felt a strong sense of belonging to a social group. This finding highlights a notable interpersonal relationship component to being an engineering student.

Finally, as engineering students progressed in their degree plans, they developed more complex views of engineering identity. Initially, they generally held one perception of what it meant to be an engineer, and they identified strongly with this perception. However, over the course of two years, they began to refine their perception of engineering identity. They could perceive a *stereotype* of what it meant to be an engineer, but they would describe their *experienced* engineering identity as distinctive from this stereotype. This particular finding is consistent with the results from the first phase of this investigation, which examined graduating seniors as they transitioned to engineering careers.[1]

Conclusion

While analysis is ongoing with this set of first-year engineering students, and the final themes may take a slightly different form than is presently described, the preliminary findings highlight the complex nature of how students relate to social or technical forms of engineering identity. Indeed, while they might perpetuate dominant forms of engineering discourse that appear technical, it is possible that they actually relate to their career identities through more social and interpersonal means.

To understand the social/technical ways that students identify as engineers is an important endeavor. When we recognize the ways that social elements are, somewhat naturally, included in students' concepts of what it means to be engineers, we have opportunity to leverage these social identity connections as we seek to develop sociotechnical mindsets that our students can instill in engineering practice.

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