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# Unpacking Professional Perceptions: How Engineering Practitioners Define ”What Engineers Do”

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# Work In Progress: Unpacking Professional Perceptions - How Engineering Practitioners Define "What Engineers Do"


## Abstract

Understanding how engineering professionals conceptualize their own work is fundamental to developing frameworks that inform engineering education, professional practice, and ongoing development. Although the "engineering mindset" has emerged as a critical construct for understanding the values, attitudes, and thinking patterns that characterize engineering practice, limited research has explored how practitioners themselves articulate what engineers fundamentally do. This work-in-progress study investigates how engineering professionals describe what engineers do through qualitative analysis of open-ended survey responses collected as part of a larger study on engineering mindset. We launched an IRB-approved online Qualtrics survey targeting practicing engineering professionals across diverse disciplines and experience levels. In this study, we include data from 30 participants. Each participant answered one open-ended question, "In your own words, explain what does an engineer do?" Using a qualitative approach, we analyzed these 30 responses through iterative coding and categorization of emergent patterns in how professionals conceptualize engineering work.

The results indicate the presence of five themes, which are: core problem-solving practice, technical design and application of science, system constraints and process management, societal impact, safety, and human focus, and communication and engineering roles. These themes represent engineering activities, technical expertise, and professional competencies that an engineer may need to develop to be a successful practitioner. Considering these results, the next steps are to continue data collection and increase diversity in experience levels, triangulate practitioner responses with other measures of engineering mindset, and explore how these practitioner-generated conceptions can inform educational strategies that better prepare students for the multidimensional and socially embedded nature of professional engineering work.


## Introduction

Engineering education stakeholders increasingly invoke “engineering mindset” to describe a collection of characteristic ways of thinking and problem-solving that engineering programs should develop, yet this construct is often discussed from the perspective of curricular goals rather than the lived experiences and practices of engineers. Frameworks emerging from engineering education and K-12 portray engineering mindset as involving systematic problem solving [1], [2], designing under constraints [3], and a belief in one’s capacity to grow as an engineer [4]. However, these frameworks are rarely grounded in exploration of whether these emphases reflect how practicing engineers describe their day-to-day work. Practicing engineers are uniquely positioned to identify which cognitive, interpersonal, and ethical orientations matter in contemporary engineering roles because they routinely translate formal training into decisions, navigate competing trade-offs, and coordinate across disciplines within complex socio-technical environments. Their perspectives can surface aspects of engineering work that receive limited attention in educational framings of engineering mindset, including navigating institutional constraints, coordinating across disciplinary boundaries, and managing uncertainty. All of these aspects could be critical for long-term professional success, are often treated as secondary to technical problem-solving skills. This work-in-progress paper begins to investigate how engineering practitioners describe what engineers do and aims to use these accounts to refine a conceptual understanding of engineering mindset grounded in practice rather than solely in learner-focused theory. This study treats the engineering mindset not as a fixed theoretical construct but as a concept still taking shape in scholarship and practice. By centering practitioners' descriptions, the work seeks to articulate dimensions of mindset that practitioners themselves identify as consequential in real workplaces, thereby grounding the construct in authentic professional contexts rather than in learner-focused theory alone. Doing so positions this study to not only corroborate existing frameworks but also surface practitioner-identified dimensions of engineering work that current frameworks may underrepresent or overlook entirely, offering an empirical basis for refining how the engineering mindset is conceptualized in both scholarship and curriculum design.

## Literature Review

Scholarly work that explicitly uses the term "engineering mindset" in higher education is still relatively recent and sparse, emerging primarily within the past decade. Much of this work has focused on learners rather than practitioners, concentrating on how students develop mindset in education contexts rather than on how practicing engineers visualize their own work. Ricco and colleagues' [5] work on exploring the engineering mindset examined engineering students' mindset using an instrument grounded in Dweck's fixed versus growth mindset framework. They documented patterns in how students interpret talent, intelligence, and their capacity to take on engineering challenges. Their results indicated that while first-year students show a bias toward the growth mindset, upper-class students exhibit a concerning 'drift' toward a fixed mindset, suggesting that educational experience may inadvertently dampen students' sense of capability.

Another study on Engineering Habits of Mind (EHoM) [6] offers a conceptually adjacent lens on engineering cognition and practice. This work has identified core habits such as systems thinking, creativity, collaboration, communication, optimism, and ethical considerations as central to expert engineering work, especially when solving societal problems. EHoM scholars argued that current practices do not consistently cultivate these habits, and they indicated the need for pedagogies and learning cultures deliberately designed to foster EHoM across K-16 settings. While highly influential for curriculum design, this work tends to conceptualize desired habits from a mix of expert consensus, literature synthesis, and educator judgment. Critically, they have been developed for engineers rather than by or with practicing engineers, potentially misaligning educational aspirations with professional realities. Other related works in this line considered how curricular interventions like biomimicry courses [7] or entrepreneurial design experiences [8], treat mindset as a set of beliefs and orientations that can be shaped through targeted learning environments. What remains underexplored is empirical scholarship that is grounded in practicing engineers' own descriptions of engineering work. Such accounts could challenge, confirm, or refine existing educational framings of engineering mindset and potentially surface dimensions of practice that scholars and educators have yet to recognize as central to professional success. To address this gap, this work-in-progress study explores the question, *"how engineering professionals describe what engineers do"* as part of a larger study [9].

Rather than testing a specific theory, the study uses practitioners' descriptions of their work as primary data for elaborating and sharpening the construct. Since the goal is to explore the concept of their understanding and assess the adequacy of existing educational framings, a conceptual framework, instead of a theoretical one, is appropriate. We are positioning practitioners' accounts as a critical reference point to capture the forms of thinking and acting that engineers see as central to their roles. Such accounts can reveal discontinuities between classroom portrayals of engineering and more realistic, practice-aligned articulations of engineering mindset. This work becomes particularly consequential at a time when engineering education increasingly invokes mindset language to justify curricular reforms and co-curricular initiatives [1]. Without explicit grounding in engineers' own descriptions, references to "engineering mindset" risk becoming internally coherent within academic literature yet systematically misaligned with professional practice. Such misalignment could undermine the efficacy of educational interventions and leave graduates unprepared for the actual cognitive and interpersonal demands of engineering work.

## Research Design

This study is part of a larger project. In the present work, we used a qualitative approach to understand practitioner participants' definitions and perspectives of engineering tasks [10]. This study does not aim to develop a formal grounded theory rather is built on conceptual framing of engineering mindset.

### *Measures to reduce bias*

Following the framework by Walther and colleagues, we consider "making the data" and "handling the data" as two procedures to minimize researchers' bias [11]. For making the data, we used a single open-ended response, and anonymity was preserved. For handling the data, multiple steps were taken. First, the codebook was developed collaboratively by multiple researchers, who then corroborated and refined the codes together. Second, we employed open coding to ensure that the analysis remained closely aligned with participants' responses. Third, multiple researchers independently analyzed the same transcripts, followed by discussions to reach consensus on the final codes and themes. Throughout these discussions, intentional efforts were made to remain faithful to participants' perspectives and to minimize the influence of researchers' personal interpretations.

### *Participants*

As we only needed responses or definitions from practitioners, we used purposive criterion sampling to recruit participants for this study [12]. Purposive sampling was well suited, as it allows ensuring the theoretical validity by capturing the diversity and multiple perspectives of participants [11]. Also, the approach permits the recruitment of participants who best serve the purpose of the research. We recruited and collected data from 30 participants. The sample comprises participants across 15 distinct disciplines, with Mechanical Engineering representing the largest group at 23.3% of respondents, followed by Civil Engineering and Computer Science at 13.3% each. Notably, 30% of respondents selected multiple majors, while the remaining 70% reported a single-major specialization. Participants ranged from early-career to senior-level professionals, though the distribution across experience levels was uneven in this preliminary sample. Because this is a work-in-progress study, we acknowledge that the current sample does not yet allow systematic comparison across disciplines or career stages. The larger data collection effort is designed to recruit a more balanced distribution of experience levels and disciplines, which will enable such comparisons in subsequent analyses.

*Data Collection*

The data were collected using a survey questionnaire with one question to collect participants perspective on the role of engineers. The open-ended question was: "In your own words, explain what does an engineer do?" Due to the rich nature of responses, the 30 responses provide enough information to begin defining the role of engineers in today's context from practitioners' perspectives. We used Qualtrics form to collect the data.

*Procedure and Data Analysis*

We analyzed the responses using inductive qualitative content analysis and thematic analysis. Inductive thematic analysis is a well-suited strategy as the themes emerged from the data [12]. The following steps were taken:

1) Two researchers read each response and became familiar with the breadth of the data
2) Two researchers independently developed the initial codebook using the first response and continued to evolve the codebook as analysis progressed. After the point of saturation, both researchers discussed and consolidated their respective codes.
3) The researchers together categorized the codes into emergent themes based on similarities in the codes. They also named the themes to reflect the tasks described as an engineer role or tasks they perform.

**Results**

Preliminary analysis revealed five distinct themes characterizing how engineering professionals conceptualize their work. Theme prominence was assessed using frequency across responses and the depth and specificity with which participants described each idea. Across the dataset, Core Problem-Solving Practice and Technical Design appeared most frequently and were often described in detail, while Communication and Systems themes were also widely represented with strong practical specificity. Societal Impact appeared across multiple responses but was typically less elaborated.

*Core Problem-Solving Practice*

Problem-solving was the most consistently represented theme, appearing in the majority of responses and often described as a systematic, iterative process. Practitioners described engineering as identifying, analyzing, and refining solutions through repeated cycles of implementation and testing. Representative statements included: *"Solves problems"*, *"An engineer solves problems, usually involving the scientific method of iteration to improve and optimize existing processes," "Systematically analyze problems to create solutions,"* and *"An engineer finds, implements, and tests solutions to problems."* The frequency and process-oriented detail of these responses indicate that practitioners view problem-solving as the central organizing activity of engineering work.

*Technical Design and Application of Science*

Closely aligned with problem-solving, this theme also appeared in a majority of responses and was frequently described with strong technical grounding. Engineers described themselves as applying scientific principles to design, investigate, and realize solutions to real-world challenges. Illustrative responses included: *"Apply math (chemistry, physics, biology) in ways that affect the world, hopefully positively," "Design, investigate and solve everyday problems," "An engineer designs and builds… Everything the engineer does must be based on sound, engineering principles," "Uses knowledge of scientific principles to design or improve new or existing items or systems and processes," and "Addresses problems/opportunities through the creation of products and services using scientific principles."* Compared to problem-solving, this theme was more explicitly tied to disciplinary knowledge and technical legitimacy, reinforcing the role of science as a foundation for engineering action.

*System, Constraints, and Process Management*

This theme appeared in many responses and was notable for its specificity and practical orientation. Respondents characterized engineering as navigating systems with multiple variables, budgets, schedules, and technical requirements. Representative statement included: *"Build complex systems with multiple variables of consideration rather than difficulty", "Solves an acceptable amount of a problem within a budget,"* "*An engineer is responsible for designing a widget within given parameters that can then be created in reality." "Analyze a problem, develop requirements, develop solution options (including pro/con, costs, schedule, recommendation) for management, and further develop the selected path through implementation,"* and *"As a graduate, the responsibility of an engineer was to manage the process".* While slightly less universal than problem-solving, this theme was often described in concrete, experience-based terms, highlighting practitioners' emphasis on feasibility and trade-offs in real-world contexts.

*Societal Impact, Safety, and Human Focus*

This theme appeared across several responses but was generally less elaborated than other themes. Responses emphasized public safety, societal benefit, and attention to human challenges, suggesting that practitioners understand engineering as inherently connected to human welfare and environmental responsibility. However, these descriptions tended to remain broad and aspirational rather than detailed accounts of how societal considerations shape day-to-day engineering decisions. Representative statements included: *"Keep the public safe," "Apply math (chemistry, physics, biology) in ways that affect the world, hopefully positively," "Improves life of society," and "An engineer creates solutions to challenges faced by humans."* This pattern suggests the presence of the theme in practitioners' thinking, but with comparatively lower depth and specificity in articulation.

*Communication and Engineering Roles*

Communication and translation emerged in a substantial portion of responses and were often described with conceptual clarity. Respondents described engineering work as involving translation between scientific and lay perspectives, client communication, and multidisciplinary coordination. Representative statements included: "*An engineer is a problem solver… and is able to communicate those solutions to the client," "An engineer serves as a translator between* *science and the lay world… taking creating new 'things' to solve 'lay' problems using 'science',"* and *"At its core, engineering has evolved into the art of problem-solving… If problem-solving is your primary job… you're essentially practicing engineering in some form."* Although not as universally mentioned as problem-solving, this theme stood out for its distinct framing and its divergence from traditional educational emphases, indicating strong analytical salience.

**Discussion and Conclusion**

The five themes reveal a multifaceted understanding of engineering practice grounded in problem-solving and technical foundations while encompassing pragmatic systems thinking, societal impact, and communication dimensions. While this convergence partially aligns with contemporary engineering mindset frameworks, the practitioner-generated themes also advance these frameworks in important ways. Existing educational framings tend to center on technical problem-solving and design thinking as the primary dimensions of engineering cognition, yet our participants described communication, constraint management, and translation with a level of concreteness and specificity that current frameworks do not proportionally reflect [13]. The prominence of systems and constraint thinking reflects practitioners' pragmatic understanding that engineering involves navigating competing criteria and real-world limitations. Most significantly, practitioners explicitly recognize communication and translation as core engineering roles. This emphasis echoes prior accounts of engineering design as an act of translation between theory and reality and among stakeholder and disciplinary languages. Research demonstrates that engineers spend approximately 60% of their time engaged in communication and collaboration [14], yet educational frameworks often treat communication as supplementary. Foster [15] describes engineering design as a translation between theory and reality, stakeholder languages, and disciplinary perspectives, and professional identity research reveals that early-career engineers expand their identity to encompass stakeholder responsibility and communication, making these relational dimensions central to their understanding of professional engineering roles rather than peripheral skills [16]. Taken together, the five themes suggest that practitioner conceptions of engineering work are broader and more relationally oriented than the technically centered definitions that dominate educational framings of engineering mindset, indicating that the construct itself may need to be expanded to account for these dimensions.

The relative underdevelopment of the societal impact theme raises important questions about practitioners' depth of engagement with the broader consequences of their work [13]. Practitioners acknowledged that engineering should "keep the public safe" and "improve life of society," but these statements remained broad and aspirational rather than concrete descriptions of how societal considerations shape daily practice. This pattern is consistent with El-Zein and Hedemann's argument that the profession's dominant self-definition as "problem solvers" can obscure the value-laden nature of engineering decisions, and with Cech's finding that engineering students' public welfare concerns actually decline across their undergraduate education. Our analysis shows a similar pattern in practitioner discourse: societal impact appears across multiple responses but is described with less depth and specificity than technical or procedural dimensions. This underdevelopment is itself a significant finding: it suggests that even when practitioners hold positive orientations toward public welfare, they may lack the reflective vocabulary to articulate how societal considerations concretely shape their decisions, a gap with direct implications for how engineering education approaches ethics and social responsibility instruction [17].

Two findings were surprising given existing educational framings of engineering mindset. First, the strength with which practitioners described communication and translation roles was striking; respondents characterized engineers as translators "between science and the lay world," framing communication not as supplementary but as constitutive of engineering work. This aligns with accounts of engineering design as a fundamentally translational practice that requires moving among multiple representational and stakeholder languages. Second, the pragmatic specificity of the Systems, Constraints, and Process Management theme was notable, with practitioners speaking concretely about budgets, schedules, and trade-offs rather than in the abstract terms typical of educational framings of constraint-based design. These surprises point to a recurring pattern: practitioners describe engineering in terms of what they actually spend their time doing, and these descriptions do not map neatly onto the hierarchy of competencies that engineering education typically presents, where technical analysis is primary and communication and constraint navigation are secondary. These gaps between education and practice suggest that engineering programs could benefit from (a) repositioning communication activities as core disciplinary experiences rather than peripheral professional skills, (b) incorporating authentic constraint scenarios that mirror the "constrained optimization" practitioners described, and (c) embedding reflective practices throughout the curriculum that help students build the professional language to articulate the societal dimensions of their work, not only learn about them.

As data collection continues, future analysis will examine variations across disciplines and experience levels and triangulate results with other survey measures of engineering mindset characteristics. We anticipate that practitioners in fields with direct public-facing consequences, such as civil and biomedical engineering, may articulate the societal impact theme with greater depth, and that career stage may shape how engineers conceptualize their work, with early-career engineers foregrounding technical problem-solving and senior engineers placing greater emphasis on communication, coordination, and systems management. More broadly, this study demonstrates that practitioner-generated conceptions of engineering work can serve as a critical reference point for evaluating the adequacy of existing educational frameworks. By revealing where practitioner descriptions converge with and diverge from scholarly framings of engineering mindset, this work offers educators an empirical basis for curricular decisions grounded in the realities of professional practice rather than assumptions about what practice entails.

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