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From Blueprint to Framework: Defining the Engineering Mindset in Practice

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Abstract

This empirical research brief extends the insights introduced by the ASEE Blueprint for Inclusive Engineering Mindset and further advances understanding of a framework for engineering mindset. As engineering education confronts increasingly complex socio-technical challenges, cultivating a robust engineering mindset is essential to support adaptability and innovation among students, educators, and practitioners. While ASEE's Blueprint provides recommendations for institutional transformation but methods for assessment or a framework are limited. Despite widespread promotion of psychological constructs like "growth mindset" and the development of entrepreneurial mindset frameworks, the field still lacks a comprehensive, empirically grounded understanding of what constitutes the engineering mindset across diverse roles and contexts.

To address this gap, we designed a qualitative survey to explore cognitive dispositions, affective orientations, epistemic beliefs, and behavioral tendencies that underpin engineering engagement and problem-solving. The survey was administered to engineering students, educators, and practitioners. In this paper, we present baseline findings obtained from the survey to establish our positionality on how engineering mindset is currently perceived, while emphasizing the importance of developing a robust framework for this construct. These findings serve as the foundation of a larger study aimed at systematically mapping the landscape of perceived engineering mindset attributes and gaps. Overall, this work lays the empirical groundwork for the future development of role-spanning frameworks and instruments, with broader implications include informing curriculum design, faculty development, and policy for a more inclusive and human-centered engineering profession.

Introduction

Mindset discourse now appears in many corners of engineering education. Students encounter phrases like "growth mindset" in first-year seminars [1], faculty are encouraged to adopt learning-focused approaches in their teaching [2], and professional organizations promote engineering mindset as essential for addressing complex societal problems [3]. Yet, these conversations typically unfold within separate communities, with students, faculty, and practitioners each drawing on partial, locally situated understandings of what mindsets matter in engineering and how they are organized, rewarded, or constrained. Engineering education research has shown that beliefs about ability, effort, and failure are linked to performance, and that these beliefs shift in response to course structure and local cultures [4]. Work on faculty beliefs and practices suggests that instructors' views about who can succeed in engineering shape instructional decisions and the classroom messaging students receive [2]. Meanwhile, research on perceptions of engineering and on stakeholder expectations points to a broader landscape in which practitioners and employers use their own language to describe the mindsets needed for contemporary engineering work, often emphasizing collaboration, adaptability, and ethical responsibility [5].

This exploratory research brief examines how three engineering stakeholder groups i.e., students, faculty, and practitioners, describe what engineers do, the key characteristics for being successful in the profession, and what kinds of thinking they view as an accurate representation of good engineering. Rather than treating "engineering mindset" as a fixed construct, this research approaches mindset talk as a collection of ideas circulating across roles and settings, asking where ideas converge and where they diverge. By comparing open-ended responses from students, faculty, and practitioners, the brief aims to illuminate how expectations about "thinking like an engineer" are produced, communicated, and sometimes misaligned across the education-practice continuum. It is challenging to know whether the mindsets that students are asked to adopt, the mindsets faculty attempt to cultivate, and the mindsets practitioners rely on in their daily work are actually pointing in the same direction without a cross-stakeholder view. This brief is therefore motivated by the need to put these perspectives in conversation, by examining where these three stakeholder groups share a common picture of what a good engineering mindset and way of thinking look like, and where subtle mismatches in emphasis or language might be undermining efforts to support learning, belonging, and preparation for practice.

Literature Review

Research on engineering students' mindsets so far has largely focused on fixed versus growth mindset beliefs about intelligence and their relation to motivation, help-seeking, and academic performance [6]. Longitudinal [4] and course-based studies [6] indicate that students' beliefs about whether they can "get smarter" in engineering are sensitive to grading policies, feedback practices, and the extent to which instructors frame struggle as a normal part of learning. Work on students' perceptions of engineering shows that many undergraduates hold narrow views of an engineers' work, emphasizing solitary technical problem solving, which can limit their sense of belonging, especially for students from groups historically excluded from engineering [7]. Outreach programs and immersive experiences have been used to broaden these images, highlighting collaboration, creativity, and societal impact, thereby shaping how young people talk about what engineers do and what kind of person an engineer is [8]. Taken together, these studies suggest that students' emerging engineering mindsets are entangled with both their beliefs about ability and the narratives they encounter about engineers' roles.

Faculty beliefs function as a crucial interpretive layer between institutional rhetoric about mindset and students' everyday experience. Beyond individual beliefs about students' potential, faculty are also active storytellers about what "counts" as engineering. Discourse-analytic work by Pawley using interview and document analysis identifies "universalized narratives" that engineering faculty in the U.S.A draw on when defining engineering for themselves and others. Narratives like "engineering as applied science and math," "as solving problems," and "as making things" were identified, which present the profession as technically focused and homogeneous while downplaying social, communicative, and contextual dimensions of engineering practice [9]. These faculty narratives sit in tension with national calls to change the conversation about engineering toward messages of creativity, teamwork, and making a difference, and thus represent a powerful, if often invisible, mechanism through which disciplinary boundaries and norms are reproduced in classrooms.

Quantitative and qualitative studies of engineering faculty have documented variation in instructors' views about a students' potential, with more fixed beliefs associated with an emphasis on sorting and weeding, and more growth-oriented beliefs associated with practices that foreground formative assessment, feedback, and opportunities to revise work [2], [10]. From a students' perspective, faculty are central figures in shaping whether engineering feels like a developmental journey or an arduous filtering process. Research on undergraduate engineering student perceptions of faculty describes the latter as "adversaries" or "allies" depending on whether they are seen as supporters of student growth or as policing narrow standards of performance. Studies that probe students' perceptions of professor mindsets suggest that the messages students infer about intelligence, failure, and who belongs can matter as much as instructors' self-reported beliefs, highlighting the importance of local cultures, faculty narratives about engineering, and classroom discourse [6], [9], [11].

While much mindset research in engineering has centered on campuses, reports and studies that attend to practicing engineers provide a complementary perspective. Syntheses of stakeholder views emphasize that contemporary engineering work demands not only technical knowledge but also comfort with ambiguity, systems thinking, collaboration across disciplinary and organizational boundaries, and responsibility to diverse users. These expectations implicitly define a set of valued orientations toward uncertainty, tradeoffs, and social impact that resemble mindset constructs even when the term is not used explicitly [5]. When juxtaposed with the universalized faculty narratives that foreground engineering as abstract problem solving and making technical things, this practice-oriented work underscores a potential misalignment between how many academic engineers describe the discipline and the broader, socially embedded forms of thinking and acting that contemporary engineering practice demands. This report extends prior work by providing a direct, cross-stakeholder comparison of mindset discourse, examining where convergences and divergences occur in how students, faculty, and practitioners articulate engineering thinking and what competencies they prioritize.

Methods

This exploratory study employed a qualitative approach with descriptive quantitative elements to examine how three stakeholder groups conceptualize engineering mindset and the competencies associated with professional engineering practice. The research design leveraged open-ended survey responses supplemented by structured rating and selection tasks to capture both descriptive narratives and prioritized competencies across groups. This approach allowed for systematic comparison of language, emphasis, and convergence across students, faculty, and practicing engineers without imposing a predetermined framework of what "engineering mindset" should entail. The brief includes 25 participants distributed across three stakeholder groups: nine engineering faculty members, six engineering students, and ten practicing engineers. We recruited participants through convenience sampling from two large R1 universities. Given the exploratory nature of this work and the small sample size, we present findings as descriptive and illustrative rather than generalizable.

Data were collected via an online survey instrument containing three components. First, participants responded to open-ended prompts asking them to (1) describe what engineers do, (2) identify key characteristics for success in engineering, and (3) describe what "thinking like an engineer" means. Second, participants rated the importance of seven core competencies (problem-solving, analytical ability, technical competence, communication, teamwork, creativity, and resilience) on a 5-point Likert scale. Third, participants selected up to three essential qualities they viewed as most central to an engineering mindset. This mixed-structure approach captured both narrative reasoning and explicit prioritization, enabling comparison across groups. Due to insufficient data at the time, responses were summarized to identify patterns, convergence, and emphasized competencies across stakeholder groups. Open-ended survey responses were reviewed and organized by stakeholder groups, with attention to recurring language, common themes, and areas of emphasis. Quantitative rating and selection data were summarized descriptively, calculating frequencies and distributions to identify consensus and variability across respondents. This summary approach enabled identification of where stakeholder perspectives aligned and where they diverged, foregrounding convergence in language and priorities without imposing predetermined coding schemes.

Results

The findings from this pilot study point to an engineering mindset that is broader and more practice-oriented than many existing framings in the literature. Faculty, students, and professionals all moved beyond viewing engineering as simply "solving problems," instead emphasizing engineering as a systematic, iterative cycle of design, testing, and refinement oriented toward improving systems for people and communities. Their perspective aligns with practice-oriented concepts of engineering mindset that foreground how engineers engage with open-ended problems, rather than defining in terms of static traits alone.

Faculty

All nine engineering faculty respondents defined engineering as problem-solving grounded in mathematical, scientific, and iterative principles to create stakeholder value while weighing ethical, social, and environmental factors, with consistent emphasis on systems thinking and prototyping. Respondents described engineering thinking as a systematic process that breaks complex problems into components while integrating creative ideation, stakeholder engagement, and resilience in the face of uncertainty. Notably, faculty explicitly noted curiosity and out-of-the-box approaches as central to engineering cognition, suggesting that educators conceptualize engineering thinking not simply as technical execution but as an iterative process within open-ended and real-world contexts.

On importance ratings (1 to 5 scale), all nine faculty assigned problem-solving the maximum value of 5, followed by analytical ability (all rated 4 or 5), curiosity and resilience (also rated 4 or 5), and creativity, teamwork, ethics, and communication, which most often received ratings of 4 or 5 (extremely or very important). When asked to select up to three essential qualities, faculty prioritized problem-solving ability, analytical thinking, curiosity, and persistence. Regarding motivation, faculty mentioned "vision of a better place", "societal or environmental impacts, and collaboration." For coping strategies, faculty emphasized persistence through iteration (for example, "keep trying different solutions") and seeking colleague advice. Self-perception data showed that 8/9 faculty (89%) endorsed persistence, 8/9 (89%) agreed that the engineering mindset "can be learned", and 7 of 9 (78%) faculty endorsed communication confidence, suggesting faculty center iterative problem-solving with curiosity and resilience while emphasizing ethical responsibility.

Students

All six student respondents defined engineering as problem-solving grounded in math, science, and iterative design to create practical solutions within constraints like cost, safety, and performance, with consistent emphasis on societal impact and ensuring reliability and efficiency. Respondents described engineering thinking as a systematic process that breaks complex problems down using curiosity, data, creativity, and iteration to refine designs. Students also noted that planning tasks with emphasis on learning from failures is central to engineering cognition, suggesting that students conceptualize engineering thinking as structured yet adaptive knowledge building for real-world improvement.

On importance ratings, all six student respondents assigned problem-solving the maximum value of 5, establishing unanimous consensus on this core competency, followed by curiosity, ethics, communication, technical competence, and analytical ability, all rated very to extremely important (i.e., 4 or 5). When it came to the selection of essential qualities for engineering mindset, students again prioritized problem-solving ability, curiosity, and continuous learning, followed by communication, teamwork, creativity, and innovation. Regarding motivation and coping strategies, intrinsic satisfaction from meaningful societal impact (for example, "help communities avoid flood impacts") and learning or growth drove persistence. All respondents reported relying on "keep trying different solutions until something works" and "talk to others for advice/feedback" when facing complex challenges. Self-perception assessments revealed unanimous endorsement for persistence, comfort with iteration, and the belief that an engineering mindset can be learned. These patterns suggest that students internalize iterative experimentation and growth orientation as core to engineering identity, foregrounding societal benefit as a motivational anchor.

Professionals

All 10 practicing engineering respondents are defined engineering as problem-solving grounded in scientific and mathematical principles, with consistent emphasis on communicating solutions to diverse audiences. Part of the findings of this section of the survey are elucidated in [12]. Respondents described engineering thinking as a systematic process that breaks complex problems into solvable components while integrating creative innovation in generating and refining solutions. Notably, several respondents explicitly invoked intellectual humility and comfort with uncertainty as central to engineering cognition, suggesting that practitioners conceptualize engineering thinking not simply as technical execution but as an iterative, epistemically humble approach to knowledge-building within real-world constraints. On importance ratings (1 to 5 scale), all 10 respondents assigned problem-solving the maximum value of 5, establishing near-universal consensus on this core competency. Analytical ability and technical competence followed closely in the 4 to 5 range, while communication, teamwork, creativity, resilience, and curiosity received more variable ratings. When asked to select up to three essential qualities for an engineering mindset, problem-solving ability and analytical or critical thinking each received nominations from 9 of 10 respondents, followed by creativity and innovation (6 selections) and communication and teamwork (5 selections). This pattern reveals that practitioners prioritize systematic thinking processes as foundational, with creative ideation and interpersonal collaboration as important supporting competencies.

Regarding motivation and coping strategies, intrinsic satisfaction, and the emotional reward of accomplishment were central to engaging with difficult engineering problems. When facing complex challenges, all but one respondent reported relying on persistence and iterative trial-and-error approaches, with seeking advice from colleagues as a secondary strategy. Self-perception assessments revealed the strongest endorsement for persistence in problem-solving (5 of 10, 50% strongly agreed) and comfort with multiple iterations (6 of 10, 60% strongly agreed), indicating engineers internalize experimental methodology and failure-as-learning as core to professional identity. A clear majority (6 of 10, 60% strongly agreed) indicated that engineering mindset can be learned and developed rather than being fixed, supporting constructivist models of engineering competency. Communication confidence showed greater heterogeneity, with only 3 of 10 (30%) agreeing they could confidently explain engineering concepts to non-technical audiences, suggesting communication remains a gap area or discipline-specific challenge.

These findings suggest that engineering professionals organize their discipline around problem-solving methodology, analytical rigor applied creatively, and persistence through iteration, underpinned by communication and collaboration skills. The universal emphasis on problem-solving contrasts with more variable emphasis on resilience and adaptability, indicating that engineering education may benefit from explicit curricular attention to failure tolerance and emotional resilience in problem-solving contexts. The distinction between communication's moderate trait importance rating and its higher identification as an enabling quality suggests that practitioners may differentiate between communication as a measurable skill and communication as a mechanism for translating individual technical work into organizational impact, warranting more targeted instructional approaches.

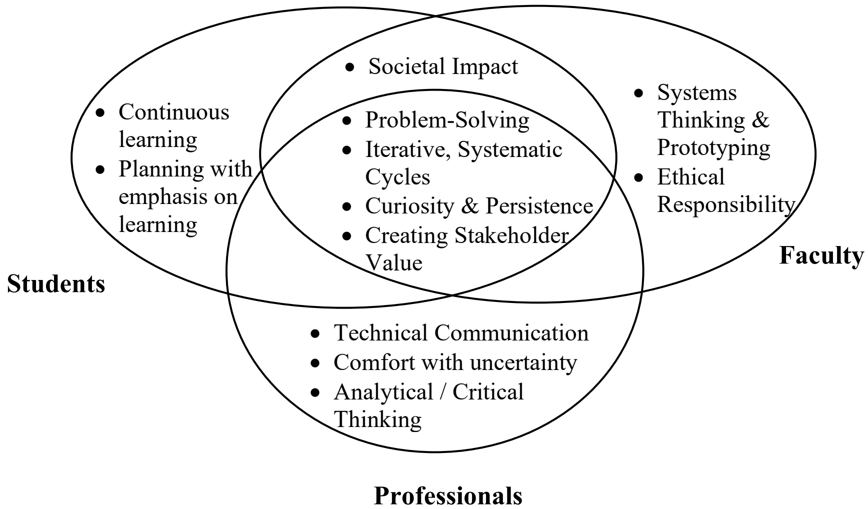

Fig 1: Converging views of Engineering Mindset across Faculty, Students, and Professionals.

Discussion

Despite operating in distinct contexts, students, faculty, and practitioners in this sample converge substantially on the engineering mindset as grounded in systematic, iterative problem-solving combined with persistence through failure. The universal consensus among professionals on problem-solving's importance, paired with students' and faculty's emphasis on iteration and struggle as normal, reveals a cross-stakeholder recognition that engineering thinking centers on decomposing complex problems, applying analytical reasoning, and refining solutions through testing and feedback. Critically, 6 of 10 (60%) of professionals in this sample view the engineering mindset as developable rather than fixed, offering preliminary support for growth-oriented pedagogies already advocated in the literature. These convergences suggest opportunities for more coherent curriculum design grounded in authentic practice perspectives. However, an important gap emerges around communication: while professionals identified it as an essential quality, only 3 of 10 (30%) reported confidence in explaining engineering concepts to non-technical audiences, suggesting a disconnect between the valuing of communication and its cultivation in practice. Engineering education can leverage the broad stakeholder consensus on core processes while intentionally addressing communication as integral to professional success, not ancillary to technical competence.

The expansive, multidimensional understanding of engineering mindset evident across all three groups suggests that narrow framings reducing mindset to fixed versus growth beliefs about intelligence are insufficient. Rather, students, faculty, and practitioners invoke systematic processes, creative adaptation, ethical reasoning, and social orientation as central to what good engineering entails. These preliminary findings add cross-stakeholder support to practice-oriented frameworks that define engineering mindset more broadly than trait-based models. Future research should expand the participant base beyond this study's limited sample (especially the six-student cohort) and collect systematic demographic data to examine whether these patterns hold across diverse institutional contexts, majors, and student identities. Longitudinal investigation of how mindsets develop across educational and professional trajectories, coupled with observational data on how stakeholders enact mindsets in practice, would enrich understanding beyond these self-reported perspectives and strengthen implications for instructional design and professional preparation.

Conclusion

This empirical research brief demonstrates that the engineering mindset, when examined across the education-practice continuum, is substantially more multifaceted and interconnected than some current educational framings acknowledge. Students, faculty, and practitioners converge on viewing problem-solving, iteration, and persistence as central, yet each group brings distinct emphases that enrich our understanding of what engineering thinking entails. The alignment on core processes suggests opportunities for more coherent curriculum design and messaging, while identified gaps in communication confidence and variable emphasis on adaptability point toward areas where engineering education can more intentionally cultivate valued competencies in dialogue with practice. By centering stakeholder perspectives rather than imposing a predetermined definition of mindset, this research opens pathways for more authentic, practice-grounded approaches to supporting student learning and professional readiness. Future research should expand the participant base, longitudinally track mindset development, and examine how curricular and cultural interventions grounded in this cross-stakeholder understanding can strengthen both engineering identity and educational outcomes.

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