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Rigor with Compassion in Engineering Education

Dr. Nina Kamath Telang, University of Texas at Austin

Nina Telang is a Professor of Instruction in the Department of Electrical and Computer Engineering at the University of Texas at Austin. She received the B.Tech degree in Engineering Physics from the Indian Institute of Technology, Mumbai in 1989, and the M.S. and Ph.D. from the University of Notre Dame in 1992 and 1995.

Diya Nair, University of Texas at Austin

Work in Progress: Rigor with Compassion in Engineering Education

Abstract:

In this work-in-progress paper, we investigate the concept of ***rigor with compassion*** in undergraduate engineering education by centering students' perceptions of academic challenge, instructional practices, and course structures. Engineering programs are renowned for their rigor, demanding workloads, and emphasis on technical mastery. However, this culture of rigor often comes at the expense of student well-being, confidence, and sense of belonging. The emerging concept of rigor with compassion challenges the long-held notion that academic excellence and empathy are mutually exclusive.

Demanding workload in engineering programs is a major source of stress, shaping students' perceptions of what it means to *succeed and belong* in the field. Despite high levels of stress, many students face barriers—such as limited information, access issues, and cultural stigma—that prevent them from seeking professional mental health support. Overall, the findings reveal a need for systemic changes in engineering education to balance rigor with compassion and to better support student well-being.

This initiative explores how intentional classroom practices can promote both high performance and holistic support. The project engaged faculty ambassadors from key engineering departments, including Electrical and Computer, Biomedical, Mechanical, Chemical, and Aerospace Engineering. In this paper we will describe the research methodology which includes administering student surveys and student focus groups with students enrolled in lower-division engineering courses in these engineering departments, and reflective self-assessment questionnaires from the engineering faculty ambassadors. By positioning compassion as an intentional pedagogical choice rather than a dilution of rigor, this research project reframes what it means to teach and learn engineering.

This paper contributes an early synthesis of student perspectives on rigor with compassion. These insights will identify actionable themes for faculty development.

Motivation for Study:

Engineering education has a longstanding commitment to academic rigor: students must master abstract concepts, integrate theory with design, and perform under time constraints. At the same time, a growing body of work suggests that students' experience of *rigor* is shaped not only by technical difficulty but also by course culture, policies, and instructor-student relationships. When challenge is structured primarily through high-stakes assessment and inflexible rules, students may spend substantial effort managing anxiety, logistical constraints, and uncertainty—costs that can reduce learning and persistence, especially for those facing greater external burdens or weaker access to academic support.

Recent studies in engineering education describe concrete approaches for maintaining high expectations while reducing avoidable barriers. For example, work in an integrated engineering energy course during remote instruction highlights compassionate flexibility as a combination of transparent communication, adaptive course structures, and supports for self-discipline that helped students remain engaged and succeed [1]. Similarly, another research study used real-time

data to generate recommendations for instructional adaptation, including explicit calls to reduce student stress while balancing course rigor with compassion [2]. Together, these studies point to an actionable premise: rigor can be preserved (and even strengthened) when it is paired with policies and practices that enable students to focus effort on learning rather than on navigating avoidable obstacles.

Research studies argue that empathy is foundational to inclusivity in engineering education [3] and propose conceptual models that treat empathy as a teachable instructional practice that can inform the design of challenging learning tasks, instructor communication, and responses to student struggle [4]. Related work examines compassion explicitly in contexts where challenge is authentic and consequential, such as engineering service-learning and senior design; this work suggests that compassion can shape students' engagement with community partners and the meaning they make of rigorous design work [5]. Finally, emerging research investigates contemplative and reflective pedagogies as mechanisms for strengthening compassion, belonging, and self-empowerment in engineering coursework. Work-in-progress studies examine how contemplative practices may influence compassion and belonging among undergraduate engineering students [6], while other work links contemplative approaches to students' sense of belonging in engineering [7]. Despite promising evidence and growing interest, key gaps remain: many studies are descriptive or early-stage, and there is limited integration between (a) designs that preserve rigor (e.g., meaningful practice, feedback, and standards-aligned assessment) and (b) compassion-oriented supports (e.g., flexibility, belonging, and empathic communication) within the same course context.

Motivated by growing evidence that student learning is optimized when high academic standards are paired with care, belonging, and support, our engineering school at the University of Texas at Austin sought to systematically examine how students experience rigor and compassion in their coursework. While engineering curricula are intentionally demanding, less is known about how students perceive instructional practices that challenge them while also communicating empathy, respect, and investment in their success. By surveying our students, we aim to capture their lived learning experiences, including moments where rigor felt motivating versus discouraging, and to identify instructional behaviors that foster resilience, persistence, and deep engagement. These insights will inform faculty development and curricular design efforts that promote compassionate challenge - maintaining disciplinary rigor while cultivating learning environments where students feel supported, valued, and capable of meeting high expectations.

Research Questions:

To better understand how rigor and compassion are experienced in our engineering classrooms, this study centers student voices as essential evidence for shaping effective and nurturing educational practices. The following research questions guide our inquiry into students' perceptions of their learning environments, their experiences of academic challenge, and the instructional practices that most meaningfully support their engagement and success.

1. How do students perceive and describe the overall learning environment in their engineering courses?
2. What does academic rigor mean to students in the context of their engineering coursework, and how do they experience it?

3. Which elements of compassion and rigor in engineering courses have most influenced our students' engagement and academic success, and in what ways?

Design and Implementation:

For the first phase of this research, rigor and compassion were examined solely from the student perspective in early engineering coursework. This phase targeted first- and second-year students enrolled in large introductory courses offered by Biomedical, Mechanical, Chemical, and Aerospace Engineering programs in our engineering school. Focusing on first- and second-year engineering students allows this study to capture perceptions of rigor and compassion at a formative stage of the academic experience, when students are still developing their identities, study strategies, and sense of belonging within the discipline. Early coursework often serves as a gateway to engineering programs, and students' experiences during this period can significantly influence their persistence, motivation, and academic confidence. By examining these early-stage experiences, the study aims to identify how instructional practices shape students' initial encounters with challenge and support, and to uncover opportunities to foster a learning environment that promotes both rigor and sustained engagement. Our research team believed that this project design would best help us answer our research questions.

The study utilized a mixed-methods approach which combined both quantitative and qualitative data collection methods. A student survey instrument was administered, and a focus group was conducted. The survey collected quantitative measures and qualitative responses to establish a baseline of students' current experiences with rigor and compassion. The focus group then provided deeper qualitative and anecdotal insight into how these dynamics appear in students' lived learning experiences.

Survey Instrument Design

The survey was designed to capture students' perceptions of both *support* and *learning climate* in early engineering coursework. It consisted of two complementary components: Likert-scale items measuring perceived instructional support and open-ended questions probing students' experiences of rigor and compassion. The survey was administered online and anonymously in the first and second-year engineering classrooms. Participation was optional.

The survey instrument included four Likert-scale questions (1–5) focused on help and support.

1. To what extent do professors provide support when students encounter challenging material?
2. How supportively do professors respond to student questions?
3. How well does the course structure encourage and support help-seeking behaviors?
4. To what extent do professors provide support to students during academic setbacks?

In the same survey, four open-ended questions asked students to describe:

1. How would you characterize the overall learning environment in your engineering classes? Are there opportunities for demonstrating compassion among peers? If so, then please describe.
2. How would you describe academic rigor in engineering coursework? Do you believe compassion and academic rigor can go hand-in-hand in engineering classes? Please explain.
3. Which aspects of compassion and rigor in your engineering courses have had the greatest impact on your engagement and success so far?

4. In your engineering courses, have you experienced teaching practices that felt compassionate? Please describe any examples.

The first three open-ended questions directly addressed our first three research questions, while the fourth open-ended question was included to help us understand the level of student awareness of the instructional practices in engineering classrooms that were compassionate.

Focus Group Design

The focus group component was designed to gather deeper insights into students' perceptions of rigor and compassion in their engineering courses. Two separate focus group sessions were conducted, each lasting approximately 60 minutes and moderated by the research team. Participants were recruited across different engineering disciplines and from the same classrooms that the surveys were administered. These groups were held in small, discussion-based settings to encourage open dialogue. Both sessions followed a semi-structured discussion protocol with pre-prepared questions listed in Table 1 below. The questions investigated how students define *academic rigor* and *compassionate learning environments*, the way these qualities appear in their courses, and how they influence motivation and engagement.

Topic	**Questions**
Academic Rigor	How do you personally define or recognize academic rigor in your engineering studies?
	What makes an engineering course feel particularly challenging or intellectually demanding to you?
Compassionate Teaching	Can you share an experience where an instructor showed understanding or flexibility that positively affected your learning?
	Have there been moments when an instructor's empathy or support helped you persist through a difficult assignment or exam?
Learning Environment and Peer Compassion	How would you describe the sense of community or support among students in your engineering classes?
	In what ways do your classmates or teams show care or encouragement toward one another in rigorous courses?
Intersection of Compassion and Rigor	What does it look like when compassion and high expectations are balanced effectively in an engineering course?
	Have you experienced a class where compassion enhanced rather than reduced academic rigor? What made that possible?
Impact on Engagement and Success	How have supportive or compassionate teaching practices influenced your motivation and performance in engineering?
	Which classroom behaviors or policies best help you stay engaged and succeed when coursework becomes demanding?

Table 1: Focus Group Questions

The survey and focus group were administered after IRB approval and consent forms were received from all participants. In the findings section below, we will report the themes that emerged, and in the future work section we will discuss our proposed framework for a faculty self-assessment questionnaire.

Findings:

This section presents findings from the student surveys and the student focus group discussions. Survey responses were collected from 92 undergraduate engineering students across multiple disciplines, including Mechanical Engineering, Biomedical Engineering, Aerospace Engineering, and Chemical Engineering. The analysis integrates qualitative themes from free-response items with descriptive statistics from Likert-scale questions to characterize how students experience rigor, compassion, and their intersection in engineering coursework.\

Overall, students described engineering learning environments as demanding yet variably supportive. Table 2 summarizes student perceptions of instructor support and course structures that enable learning in challenging engineering contexts. Overall, mean ratings were consistently high (≥ 4.0 on a 5-point scale), indicating that students generally perceive their instructors as supportive and responsive. However, qualitative responses revealed substantial variation in how compassion is experienced across courses, class sizes, and instructional contexts.

Survey Item	**Mean (1–5)***
Professors provide support in challenging material	4.20
Professors respond to questions supportively	4.43
Course structure supports help-seeking	4.15
Professors provide support during setbacks	4.00

*Responses collected on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).
Table 2: Student Perceptions of Instructor Support and Course Structure

Table 3 below presents a thematic synthesis of open-ended student survey responses, organizing emergent themes by survey question and pairing them with representative student quotes to illustrate how rigor and compassion are experienced in engineering coursework. Together, the themes and quotes foreground students' perspectives on peer culture, instructional practices, and course structures that shape perceptions of compassionate rigor across engineering learning environments.

Survey Question	**Themes Identified**	**Representative Student Quotes**
How would you characterize the overall learning environment in your engineering classes?	● Collective peer compassion and collaboration. ● Structurally embedded opportunities for connection. ● High workload pressure and individual focus.	*Working on homework together is always an opportunity to show compassion.* *When we have time to work on practice problems with the person next to us, that feels compassionate.* *A lot of my classes feel very competitive, and it's hard to connect with people.*

How would you describe academic rigor in engineering coursework? Do you believe compassion and academic rigor can go hand-in-hand in engineering classes?	● Supportive peer culture through shared struggle. ● Compassion as stress mitigation. ● Rigor as foundational challenge	*People bond when they struggle together.* *Just because something is difficult doesn't mean the class can't show compassion.* *Rigor should come first, but compassion helps keep morale up.*
Which aspects of compassion and rigor in your engineering courses have had the greatest impact on your engagement and success so far?	● Accessible instructor support ● Peer community ● Safety net for failure	*The openness to ask questions is very important to me.* *Helping each other understand hard concepts has had a big impact on my success.* *Challenging problems with lots of help options made a huge difference.*
In your engineering courses, have you experienced teaching practices that felt compassionate? Please describe any examples.	● Instructor availability ● Psychologically safe classrooms ● Personalized instruction in office hours. ● Lack of perceived compassion in larger classes.	*My professor's office hours are very accessible and informative.* *The teacher answers questions in a way that is not condescending.* *In large lecture classes, compassion is harder to feel.*

Table 3: Thematic Summary of Student Survey Responses with Representative Student Quotes.

Now we present findings from a thematic analysis of the two student focus group discussions examining how undergraduate engineering students experience and interpret ***rigor with compassion*** in their coursework. The analysis synthesizes recurring themes across both focus groups and highlights how instructional design, course culture, and teaching practices shape students' perceptions of rigor, support, and engagement.

Across both focus groups, students consistently described rigor as a multidimensional construct encompassing workload, conceptual challenge, and expectations for independent problem-solving. Rigor was not perceived solely as the volume of assignments or exams, but also as the cognitive shift required to apply concepts in unfamiliar contexts. Students emphasized that courses demanding abstraction, transfer of knowledge, and deep conceptual reasoning, in areas such as circuits and electromagnetics, were experienced as highly rigorous. Importantly, students distinguished between productive rigor and unnecessary difficulty, noting that misalignment between lectures, practice problems, and assessments amplified stress without improving learning.

Compassion, in contrast, was framed less as reduced academic standards and more as the creation of a psychologically safe and supportive learning environment. Students repeatedly emphasized that compassion was communicated through instructor approachability, nonjudgmental responses to questions, and a visible willingness to support student learning. Compassionate teaching behaviors included instructors and teaching assistants who normalized confusion, encouraged questions, and treated mistakes as part of the learning process rather than as evidence of deficiency. Students described classrooms with these qualities as spaces where they felt comfortable engaging, even when the material itself remained challenging.

A central theme across both focus groups was the role of instructional scaffolding and access to resources in enabling students to meet high expectations. Students highlighted lecture recordings, annotated slides, practice problems, review sessions, office hours, and TA-led clinics as critical supports that allowed rigor to remain intact while reducing barriers to understanding. These resources were not viewed as lowering standards; rather, they were described as tools that helped students persist through difficult material. One frequently cited example involved an instructor who paused a make-up exam upon realizing widespread misconceptions, provided real-time instruction on the core concept, and then reconnected the material to its real-world application. Students interpreted this action as a clear demonstration of compassionate rigor—maintaining high expectations while responding to students' actual learning needs.

Peer interaction and a sense of belonging also emerged as essential components of compassionate rigor. Students described structured peer activities such as think–pair–share, rotating partners, labs, and group projects as mechanisms that normalized struggle and reduced isolation. Beyond the classroom, "third spaces" such as learning lounges, tutoring centers, and informal study groups played a critical role in fostering community. These spaces, often supported by near-peer mentors or teaching assistants, helped students feel that they were part of a collective learning process rather than navigating challenges alone.

Predictability and trust were identified as foundational to students' perceptions of fairness and compassion. Students valued clearly communicated expectations, consistent assignment rhythms, and stable assessment policies. Sudden mid-semester changes—such as shifts in grading schemes or assessment formats—were described as "sharp edges" that undermined trust, even when implemented with good intentions. When changes were unavoidable, students expressed a strong preference for transparent communication, phased implementation, and compensatory supports such as additional practice or reduced stakes.

Finally, students articulated those experiences of compassionate rigor had a meaningful impact on their motivation and persistence. When pressure related to grades was moderated through mechanisms such as curves, dropped assignments, or deadline flexibility, students reported being better able to focus on learning and building durable conceptual foundations. Many students described developing greater patience, resilience, and empathy because of navigating challenging coursework within supportive environments. These outcomes extended beyond immediate academic performance, shaping how students approached future engineering courses and collaborative work.

Taken together, these findings suggest that students do not view rigor and compassion as opposing forces. Instead, they perceive compassionate rigor as a learning environment in which high expectations are paired with intentional support, consistency, and respect for students' lived experiences. Such environments promote deeper engagement, sustain motivation, and support both academic success and professional growth in engineering education.

Future Work:

Our research thus far has focused on students' voices to better understand how rigor and compassion are experienced in engineering classrooms, with particular attention to course structures, instructional practices, and learning cultures that support or hinder student engagement and success. The next step in our study is to administer a faculty self-assessment questionnaire drawn from these student insights. This framework is designed for engineering instructors to reflect on how rigor and compassion are balanced within their courses. Table 4 presents a proposed framework for this questionnaire. The framework is intended as a reflective tool rather than an evaluative instrument. Its purpose is to help instructors identify areas where high academic expectations may be productively supported through course structure, instructional culture, and intentional design choices.

The framework conceptualizes rigor as a multidimensional construct that extends beyond workload alone. In engineering courses, rigor often manifests through conceptual depth, abstraction, cumulative prerequisite knowledge, and sustained cognitive effort. While these elements are foundational to engineering education, students' experiences suggest that rigor becomes counterproductive when it is paired with limited instructional support or inconsistent policies. Accordingly, the first dimension of the framework focuses on identifying ***Sources of Rigor*** so that instructors can explicitly recognize where students are likely to encounter difficulty.

The second dimension, ***Structural Safety Nets***, emphasizes institutionalized mechanisms that reduce risk without diluting academic standards. Rather than relying on ad hoc accommodations, this dimension encourages instructors to consider whether flexibility is embedded into the course design itself. Policies such as dropped assignments, grading adjustments, deadline flexibility, and policy consistency function as trust-building measures that allow students to engage deeply with challenging material while maintaining a sense of fairness and predictability.

The third dimension, ***Culture and Accessibility***, addresses the interpersonal and relational aspects of teaching that strongly shape students' perceptions of compassion. Research and student feedback consistently demonstrate that instructor approachability, normalization of struggle, and accessible support structures play a critical role in sustaining engagement in rigorous courses. This dimension prompts instructors to reflect on how their behaviors, communication practices, and availability signal whether help-seeking is welcomed and supported.

The final dimension, ***Course Design***, focuses on how assessments, learning activities, and relevance cues reinforce or undermine compassionate rigor. Learning-oriented assessments, opportunities for reflection, peer-support structures, and real-world connections help students interpret rigor as meaningful rather than punitive. By distributing assessment weight and

incorporating collaborative and applied components, instructors can emphasize conceptual understanding and professional preparation over short-term performance alone.

This framework provides a holistic lens for instructors to examine how rigor is experienced in their courses and how compassion can be intentionally embedded through design, policy, and pedagogy. The associated questionnaire is structured as a series of reflective yes/no/not applicable prompts, allowing instructors to identify strengths, gaps, and opportunities for growth. When used iteratively, the framework can support continuous improvement efforts aimed at fostering challenging yet supportive engineering learning environments.

Framework Dimension	Rigor / Compassion Metric	Self-Assessment Question (Y / N / N/A)
Sources of Rigor	Conceptual Depth	Does the content require analysis and application of underlying principles rather than replication of examples?
	Conceptual Abstractness	Does the course rely on abstract or non-intuitive concepts that are difficult to visualize?
	Workload Intensity	Is the volume of required work consistently high across the term?
	Prerequisite Dependence	Does success depend heavily on prior knowledge that may vary widely among students?
Structural Safety Nets	Assessment Flexibility	Is there a policy allowing the lowest assessment score to be dropped?
	Grading Adjustment	Is a grading curve or norm-referenced adjustment used to contextualize raw scores?
	Deadline Flexibility	Are extensions, slack days, or makeup assessments available when needed?
	Policy Consistency (Trust)	Have grading and assessment policies remained stable throughout the term?
Culture and Accessibility	Instructor Approachability	Do I actively cultivate an inviting and respectful demeanor?
	Normalizing Struggle	Do I frame mistakes and confusion as normal parts of learning?
	Individualized Support	Do I attempt to meet students at their current level of understanding?
	Support Accessibility	Are office hours frequent, flexible, and strategically scheduled?
	Learning Resources	Does the course provide sufficient instructional resources to reduce barriers?
Course Design	Learning-Oriented Assessment	Are assessments used as feedback for improvement or revision?
	Real-World Relevance	Are challenging concepts consistently connected to real-world applications?

	Peer Support Structures	Does the course intentionally incorporate collaborative learning elements?
	Motivational Balance	Is assessment distributed to emphasize understanding over rote memorization?

Table 3: Proposed Instructor Self-Assessment Framework for Rigor with Compassion

We anticipate that integrating student insights with the faculty self-assessment will inform guidelines for cultivating compassionate rigor across engineering curricula.

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