Engineering Faculty Perspectives on Curricular Preparedness for Disruption

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Abstract:

Engineering faculty experience disruption not as isolated events but particularly in recent years, as a persistent, multi-layered condition that reshapes academic priorities, technological infrastructures, and learning environments. Faculty workplace disruptions in higher education span technological innovation, institutional restructuring, and global events, requiring faculty to translate these disruptions into evidence-based curricular responses. However, limited research has explored how faculty characterize disruptions or perceive their impacts on the skill requirements of graduates. This study addresses this gap by examining how engineering faculty perceive disruptions within their disciplines and the broader academic enterprise, recognize impacts on graduate skill requirements, and recommend curricular changes to prepare students for volatile professional futures.

A qualitative study was conducted using thematic analysis of open-ended survey responses from 13 selected engineering faculty members across multiple disciplines. The survey examined three focal questions: the basic nature of disruption in their discipline, perceived impacts on skills required for industry success, and recommended curriculum changes. Respondents reflected a diversity of career stages from less than five years to more than 30 years of experience. Results identified three major findings. First, faculty characterized disruption as cumulative and ongoing, encompassing technological waves (Internet through generative AI), pandemic-driven virtualization, institutional restructuring, energy sector transitions, and evolving learning environments. Second, while core engineering fundamentals remain essential, faculty perceive them as increasingly vulnerable under disruption conditions, and they identified adaptive, metacognitive, and relational skills, particularly verification and critical judgment of tool outputs, as new baseline competencies for graduate success. Third, faculty recommended curricular changes emphasizing explicit instruction in resilience, scenario-based pedagogies that rehearse adaptation under uncertainty, and the teaching of generalizable rather than specific tool knowledge, as well as institutional structures that balance predictable organization with modular flexibility and instructor autonomy.

The findings suggest that engineering education must shift from preparing students for traditional professional contexts to cultivating their capacity to learn and adapt amid ongoing disruption. This requires rethinking pedagogical approaches, assessment strategies, and institutional governance to develop both faculty and student preparedness. These results contribute valuable insight into faculty perspectives on disruption, offering practical implications for curriculum design, faculty development, and institutional policy. The analysis highlights pathways for fostering resilience and innovation within engineering education programs.

Keywords: disruption, engineering education, curriculum design, adaptive learning, generative AI, faculty perspectives

Introduction

Engineering faculty do not experience change as a sequence of isolated events but as an accumulation of technological, institutional, and sociopolitical forces that continually reshape the conditions of academic work. Across higher education, disruption is increasingly recognized as a systemic and multidimensional phenomenon encompassing crisis-driven shocks, such as the COVID-19 pandemic, as well as longer-term transformations, including digitalization, automation, and shifting labor market demands (Crawford et al., 2020; Dhawan, 2020; Rapanta et al., 2020). Recent scholarship shows that disruptions affect not only instructional delivery but also epistemic norms, faculty roles, and the expectations placed on graduates (Watson et al., 2024; Wu, 2022). Yet despite its growing relevance, the concept of disruption remains loosely and inconsistently defined in engineering education research.

Engineering education is particularly susceptible to disruption because its relies on hands-on practice, technological infrastructures, and close alignment with industry expectations (Castañeda & Williamson, 2021). Sudden transitions to emergency remote teaching have challenged laboratory-based curricula and assessment models (Flaig, 2021; Yang, 2022), while digital inequities have shaped unequal student learning conditions (Mok, 2022). At the same time, ongoing technological forces, including robotics, IoT, data-driven automation, and most recently, generative artificial intelligence, continue to reshape what counts is considered essential engineering knowledge (Kasneci et al., 2023; Abichandani et al., 2022). Engineering faculty are thus positioned at the intersection of rapid technological evolution, fluctuating institutional priorities, and shifting student learning behaviors. However, little research directly examines how faculty themselves characterize these disruptions or interpret their implications for curriculum and graduate preparedness.

The emergence of generative AI represents an especially acute and distinctive form of disruption. Unlike prior educational technologies whose adoption patterns unfolded gradually, GenAI tools such as ChatGPT and Gemini have spread across academic environments within months, prompting widespread debate about academic integrity, assessment design, and the evolving meaning of expertise (Dwivedi et al., 2023; Bravo & Cruz-Bohorquez, 2024). Faculty must now navigate how these tools transform their professional practices while recalibrating expectations for student competence, particularly the balance between foundational knowledge, tool-mediated performance, and emerging metacognitive skills, including verification and judgment (Francis et al., 2025). Early research emphasizes that AI-induced disruption operates simultaneously at individual, organizational, and systemic levels, requiring continous adaptation rather than one-time responses (Johri et al., 2023; Mollick & Mollick, 2024). Recent qualitative research has begun to document faculty perspectives on navigating such disruptions, revealing tensions between external technological forces and internal institutional dynamics (Raju et al., 2025). Yet questions remain regarding how faculty translate these experiences into expectations for graduate competencies and programmatic curriculum design.

While existing literature maps the macro-level effects of disruption across institutions, few studies focus on faculty perceptions within their own disciplinary contexts. This gap limits the field's ability to design coherent faculty development efforts, anticipate curriculum needs, or understand how engineering programs can prepare students for increasingly volatile professional environments. Addressing this gap, the present study investigates three questions:

- How do engineering faculty characterize the nature of disruptions affecting their disciplines?
- How do faculty perceive these disruptions as influencing the skills required for engineering graduates' success?
- What curricular changes do faculty recommend to prepare students for ongoing and future disruption?

By analyzing open-ended responses from 13 engineering faculty members across diverse disciplines, this study offers empirically grounded insights into how faculty conceptualize disruption, evaluate its consequences, and envision programmatic responses. The results contribute to an ongoing conversations about resilience, adaptive learning, and the future of engineering education.

Literature Review

Disruption in academia has been broadly defined as a significant alteration in educational systems, structures, or practices that challenges existing norms and necessitates adaptive responses (Lindsay et al, 2023). Yet consistent with findings in engineering education, most studies do not explicitly define the term, instead describing disruption implicitly through its effects on teaching, learning, and institutional stability (Tembrevilla et al., 2023). Within academic contexts, disruptions are commonly characterized along three overlapping dimensions: crisis-driven shocks, technology-driven transformations, and student-centered breakdowns. Crisis-driven disruptions are most prominently represented by the COVID-19 pandemic, which forced an abrupt transition to emergency remote teaching across institutions worldwide (Dhawan, 2020; Rapanta et al., 2020). In engineering education, these shifts exposed vulnerabilities in laboratory-based instruction, assessment practices, and student engagement, particularly in courses dependent on physical experimentation and collaborative design (Flaig, 2021; Wu, 2022). Research also documents disproportionate impacts on students with limited access to reliable technology, highlighting how disruption magnifies pre-existing inequities within higher education systems (Mok, 2022; Son et al., 2020).

Beyond acute crises, engineering education has been shaped by longer-term technological disruptions associated with digital transformation, automation, and the increasing integration of artificial intelligence. Prior to the emergence of generative AI, studies examined the influence of simulation-based learning, remote laboratories, and data-driven tools on engineering pedagogy and skill development (Aristawati et al., 2018; Yang, 2022). These technologies were generally adopted incrementally and positioned as supplements to existing instructional practices. In contrast, generative AI tools such as ChatGPT represent a qualitatively different form of disruption due to their rapid diffusion, accessibility, and capacity to automate cognitive tasks traditionally central to engineering learning, including programming, technical writing, and problem-solving (Kasneci et al., 2023; Dwivedi et al., 2023). As a result, GenAI challenges established assumptions about authorship, assessment validity, and the demonstration of student understanding.

Recent scholarship increasingly frames generative AI as a systemic disruption rather than a discrete instructional tool. Studies emphasize that GenAI adoption operates simultaneously at multiple levels, reshaping individual faculty workflows, departmental norms, and institutional governance structures (Johri et al., 2023; Jensen et al., 2024). Unlike earlier educational technologies, GenAI has spread faster than policy development, leaving faculty to navigate questions of responsible use, academic integrity, and pedagogical redesign largely on their own (Bravo & Cruz-Bohórquez, 2024). This has contributed to uncertainty and uneven adoption across disciplines and institutions, reinforcing the need to examine how faculty interpret and respond to disruption in their specific contexts.

Engineering education has long been shaped by technological innovations, from earlier shifts to simulation-based learning to contemporary interest in robotics, IoT, and remote labs (Yang, 2022; Aristawati et al., 2018). However, generative AI differs from prior technologies in both speed and scope of adoption. Became mainstream within months, had started to automate cognitive tasks once central to engineering learning (e.g., coding, writing, analysis), and had challenged long-standing definitions of authorship, originality, and disciplinary expertise. Studies had started to describe GenAI as an "unprecedentedly disruptive force" that reshapes academic practice at individual, organizational, and systemic levels (Jensen et al., 2024; Akabagy, 2024).

Engineering education is also particularly susceptible to disruption because of its close alignment with industry practices and its reliance on rapidly evolving technological infrastructures. As engineering practice increasingly incorporates AI-driven tools, automation, and interdisciplinary collaboration, the competencies expected of graduates are also shifting. Research suggests that while foundational engineering knowledge remains essential, graduates must now demonstrate additional capabilities related to digital literacy, adaptability, and the critical evaluation of tool-generated outputs (Abichandani et al., 2022; Francis et al., 2025). These shifts complicate curriculum design, as programs must balance the preservation of disciplinary rigor with preparation for uncertain and evolving professional contexts.

Beyond technology-driven change and acute crisis events, engineering faculty also experience disruption arising from institutional and structural dynamics within higher education. These disruptions include the restructuring of academic programs and units, instability in instructional resources, such as reductions in teaching assistant support, and shifts in accreditation requirements or industry-aligned expectations that reshape curricular priorities (Polanco-Lahoz & Cross, 2024). Research examining faculty experiences with disruption has found that internal institutional forces, including leadership transitions, enrollment fluctuations, and abrupt policy changes, are often perceived as equally disruptive to external technological forces, contributing to faculty stress, role ambiguity, and reduced institutional trust (Raju et al., 2025). Faculty further identify changes in the physical design of learning environments, such as the adoption of studio-style classrooms with limited visibility or constrained instructional flexibility, as disruptive to established teaching practices. Collectively, these institutional and infrastructural disruptions influence faculty professional identity, increase workload demands, and challenge the sustainability of core pedagogical approaches, particularly those reliant on interaction, iteration, and hands-on problem solving.

Despite growing attention to disruption in engineering education, important gaps remain in the literature. Much of the existing research focuses on student outcomes, institutional responses, or specific technologies, with comparatively little attention to how engineering faculty themselves conceptualize disruption across their disciplines. Recent work by Raju et al. (2025) examined faculty navigation strategies in response to technological, global, and institutional disruptions through focus group discussions. Their findings emphasize resilience, adaptability, and communication as crucial faculty competencies, while identifying internal institutional disruptions (administrative changes, policy shifts, enrollment pressures) as equally significant to external technological forces in shaping faculty professional efficacy. However, their study focused primarily on how faculty respond to and manage disruptions rather than how faculty perceive these disruptions as reshaping the skills required for graduate success or translating these perceptions into specific curricular recommendations. Moreover, few studies explicitly examine how faculty perceive disruptions as reshaping the skills required for graduate success in industry or how these perceptions translate into concrete curricular recommendations. Addressing these gaps is essential for developing coherent faculty development initiatives, responsive curricula, and institutional strategies capable of supporting engineering education in conditions of ongoing uncertainty.

Methodology

This study used a qualitative design based on open-ended responses collected via a Qualtrics survey. The analysis reported in this paper focuses on three questions from an eight-question survey: (1) "What was the basic nature of disruption in your discipline?", (2) "Do you believe this disruption meaningfully impacted the skills required for engineering graduates' success in industry and engineering/technology practice?", and (3) "What changes would you recommend in your program's curriculum to better prepare students?" The dataset comprised responses from 13 faculty with experience teaching engineering students. To protect confidentiality and reduce deductive disclosure risk, identifying information (i.e., discipline, rank, unit) was not reported, and excerpts were presented without attribution beyond generic identifiers. Qualtrics responses were exported for analysis and organized by survey question. We treated each response to a focal question as a short narrative account of disruption and preparedness, and coded at the level of meaning units (individual sentences or small cluster of sentences that expressed a coherent idea). The unit of analysis was each participant's response to each focal question. Responses were reviewed for completeness and prepared for coding without altering substantive content.

We conducted inductive thematic analysis to identify patterns in participants' responses across three focal questions. Analysis followed an iterative interpretive process of: a) familiarization with responses, b) initial coding, c) grouping codes into candidate themes, d) reviewing and refining themes for coherence and distinction, and e) defining and naming final themes supported by representative excerpts. In the first coding cycle, each researcher independently generated descriptive and process code (for example, "shifting academic priorities", "loss of rigor") directly from participants' language. We then examined how these codes clustered within and across responses, using analytic memos to preserve the temporal and causal structure of faculty narratives (for example, how they linked particular disruptions to perceived skill needs and curricular recommendations). Themes were developed inductively from patterns in the data through an iterative interpretive process rather than imposed from an a priori framework. Two researchers independently coded the dataset and compared coding decisions. Interrater reliability was quantified using Cohen's kappa yielding $\kappa = 0.876$, indicating strong agreement. Discrepancies were resolved through discussion and return to the raw responses, resulting in a final consolidated coding structure used for thematic synthesis and reporting.

Results

Using the consolidated set of themes developed through intercoder analysis, the results below synthesize how faculty characterized recent disruptions in engineering education, how those disruptions affect industry preparedness, and what changes they recommend to programs and curricula.

1. Basic Nature of Disruptions in Disciplines

When asked "What was the basic nature of disruption in your discipline?" participants described disruption as both episodic shocks (for example, COVID-19, extreme weather, discipline-specific crises) and structural shifts (e.g., digital transformation, changing institutional priorities). Across accounts, disruption was a multi-layered condition that reshapes what engineering work is, how it is taught, and what is valued as expertise, laying the context in which faculty judge whether curricula remain adequate.

Theme 1 – Shifting Academic Priorities, Digital Waves, and Expertise

A prominent disruption described a perceived shift in academic engineering away from hands-on, practice-based orientation towards a more theoretical, explanation-driven and research-centric culture. Participants contrasted earlier emphasis on designing and building with a current environment perceived to reward research productivity and funding over teaching and service.

- *"We evolved from a field with a lot of 'hands on', 'design it', or 'make it work' to a field that values explain why it maybe could work…."*
- *"a PHD and research (especially dollarism) was moved to… the top priority for programs."*

Faculty situated these changes within a longer arc of digital transformation. Rather than describing technology as a single turning point, they portrayed change as cumulative beginning with internet access and mobile devices, with AI representing a particularly impactful phase that accelerated from the 1950's through the recent generative AI emergence.

- *"Advent of the Internet, Smartphones, etc."*
- *"Advent of artificial intelligence—slow but sure from the 1950's… Now accelerating and highly impactful"*

Within this trajectory, generative AI was distinguished as a qualitatively different and more widely accessible disruption because GenAI has the potential to automate tasks or portions of tasks previously central to learning and professional practice, especially writing and coding.

- *“The introduction of easy to use generative AI tools (ChatGPT, Gemini, etc) since 2021…. Facilitates the generation of relatively coherent text and computer code (Python, C++. Etc).”*
- *“the gen AI wave currently sweeping through.”*

Participants described disruption as an acceleration in how rapidly evolving tools continually redefine what counts as essential knowledge and experiential learning, particularly when “experience” was perceived to lose status relative to tool-driven competence.

- *“We have tools evolving… that keep changing what is really important to learn.”*
- *“many people with experience do not have experience with the newest tools.”*

These perceptions of shifting expertise and tool use informed later recommendations to rearticulate core curricula and explicitly teach students how to navigate evolving tool ecosystems.

Theme 2 – Pandemic, Accidents, Weather Events, and Sectoral Transitions

COVID-19 was consistently named as a major disruption with both immediate and lasting consequences. Faculty highlighted the rapid transition to online instruction as a defining moment, as well as longer-term changes in how academic work is organized.

- *“The first key memory is the pandemic-driven 2020 shift of all teaching to the virtual environment. The transition occurred for most during Spring Break.”*
- *“COVID lockdown”*
- *“Pandemic (CCOVID); Nature of job changed;”*

Beyond pandemic disruption, faculty pointed to external shocks that reshape disciplines and their public contexts. In some fields, disruption was linked to high-profile accidents with regulatory and reputational implications.

“In Nuclear Engineering, the Fukushima Daiichi accident in Japan was a major disruptor.”

Others referenced extreme weather events that interrupted operations and course delivery.

“Ice storm recently. Hurricanes in past years.”

Faculty also described disruption through macro-level sectoral change, particularly energy-related transitions that reframe what knowledge and skills are central.

“The emergence and broad global acceptance of an 'energy transition' and the rapid development of new and renewable energy sources.”

These episodic and sectoral disruptions pushed faculty to reconsider which topics, examples, and design problems should be foregrounded in courses to maintain relevance and sector-specific preparedness.

Theme 3 – Institutional Restructuring, Learning Environments, and Sociopolitical Pressures

A further form of disruption was generated internally by institutional decisions and resource shifts. Faculty described periodic interruptions from funding transitions, program restructuring, and changes in staffing or instructional support.

- *"operations are periodically interrupted due to funding transitions."*
- *"changing in the department from 2 majors to 1 major by eliminating Health Physics majors…"*
- *"reduction of TA budget…"*

Faculty also framed disruption as embedded in changes to physical and mediated learning environments. The redesign of classrooms into studio-like, screen-dominated spaces was described as altering instructor–student visibility, interaction patterns, and pedagogical options, particularly when no alternative classroom formats were available.

- *"a fundamental change in teaching when the instructor can't see the faces of all the students…"*
- *"There is little to no space for white board problem solving…"*
- *"the disruption… is that there is no alternative."*

Participants noted that technology-saturated environments were reshaping student expectations and learning behaviors, with increased reliance on posted slides and reduced note-taking.

- *"Students have become complacent that they will 'get the slides'…"*
- *"The proliferation of slide dissemination removes any requirement that students become disciplined at attentive listening and note taking."*

Finally, some faculty explicitly named sociopolitical dynamics including DEI-related pressures as part of the disruption landscape, while others framed disruption as an enduring feature of academic life.

- *"Political or societal"*
- *"DEI"*
- *"Numerous disruptions have occurred in my time…"*

Taken together, these accounts position disruption as technological, institutional, spatial, and sociopolitical, and as a persistent condition across careers, which faculty perceive as demanding more resilient curricula, learning environments, and program structures.

2. Perceived Impacts of Disruptions on Skills Needed for Industry Success

When asked whether disruptions meaningfully changed the skills required for engineering graduates' success in industry and engineering/technology practice, faculty described continuity in core engineering fundamentals alongside a growing demand for judgment, adaptability, and digital competence. Some perceived minimal long-term skill change, while others argued that pandemic-era teaching conditions and the rise of generative AI have altered what graduates must be able to do and how reliably they can do it, directly shaping their views of what curricula must now emphasize.

Theme 1 – Fundamentals, Rigor, and Learning Discipline Under Disruption

A dominant thread emphasized that the "core" of engineering competence has not changed: graduates still require strong fundamentals and analytical reasoning.

- *"The core competencies to be a successful engineer remain the same, particularly knowledge of the fundamentals."*
- *"They still need the same engineering/analysis skills to be successful."*
- *"Generative AI is a tool, not a crutch."*

At the same time, participants framed disruption as increasing the risk that fundamentals are weakened when tools are treated as substitutes for understanding. A substantial set of responses argued that disruption, especially under the pressure to maintain throughput during remote instruction, reduced rigor and produced weaker preparation for professional practice.

- *"Yes. The virtual teaching environment and the pressure to pass students produced low-quality graduates."*
- *"Absolutely. Engineering coursework and skills were dumbed down significantly."*

Related concerns focused on learning behaviors and engagement, with disruption seen as contributing to weaker self-discipline in learning and reduced attention to skill-building practices.

- *"Students are loosing the ability to take notes and learn."*
- *"The proliferation of slide dissemination removes any requirement that students become disciplined at attentive listening and note taking."*

These perceptions motivated calls for curricular and pedagogical changes aimed at re-strengthening fundamentals, re-emphasizing disciplined learning practices, and redesigning assessments that can distinguish genuine understanding from tool-supported performance.

Theme 2 – AI/Digital Literacy, Verification, Collaboration, and Adaptability

Faculty frequently described a shift from simply "using tools" to needing strong critical evaluation of outputs, especially as AI-mediated work becomes more common. Participants argued that graduates must understand when AI outputs can be trusted, when they require verification, and how to use tools responsibly to enhance rather than replace engineering reasoning.

- *"To be more effective, our graduates should understand the basics of how to properly use AI (and when to trust or verify)."*

– *“Computer awareness and some level of proficiency is requisite for all engineering disciplines.”*

Some responses framed AI/digital literacy as a productivity-relevant competence rather than an optional add-on:

“Engineers with competence and knowledge in the responsible use of these tools have been shown to be 30–60% more productive than their peers.”

Disruption was widely described as accelerating the pace of change in tools, workflows, and constraints, making adaptability and continuous upskilling central to early-career success. Faculty portrayed this as a shift in what employers and workplaces implicitly demand and noted a gap between curriculum innovation and industry change:

“We… have not kept pace in improving our curricula for this evolution of tools and expectations.”

Participants also linked pandemic-era disruptions to increased need for effective communication and collaboration in virtual or hybrid environments.

- *“The pandemic-driven 2020 shift of all teaching to the virtual environment…”*
- *“This is not to say it was ‘easy,’ but there were resources to ‘teach from anywhere’.”*

Some faculty framed the impact as mitigated by prior experience with remote tools, while others emphasized downstream effects on preparation and rigor. Collectively, these views underscore the need for curricula that explicitly integrate AI/digital literacy, verification skills, and collaboration in digitally mediated settings.

Theme 3 – Field-Specific Recalibration and Limited Perceived Change

In some disciplines, disruptions were described as changing skill priorities through shifts in industry expectations, regulation, and public scrutiny. For example, nuclear engineering disruption was linked to increased emphasis on safety and communication, while energy-sector transitions were described as requiring broader systems thinking and transferable literacy across technologies.

- *“Fukushima… was a major disruptor… communication became more important, along with an increased emphasis on nuclear reactor safety.”*
- *“increased need for energy literacy… systems thinking… petroleum engineers applying… skillsets to develop geothermal resources, lithium extraction, CO2 sequestration…”*

These accounts highlight that disruption impacts are not uniform: they vary by discipline and are shaped by sector-specific trajectories. At the same time, some participants suggested that certain disruptions had limited enduring impact on graduate skill requirements, either because disruptions were short-term operational interruptions or because faculty practices and infrastructures already supported remote or flexible delivery.

“I don't think the impact was substantive because I put significant effort into extra class meetings, review sessions, etc.”
“For Covid (2020–2022), I don't believe there was minimal impact because we had been teaching using remote means since 1998… it was pretty seamless.”

These field-specific and heterogeneous experiences informed equally varied curricular priorities, from heightened safety and communication training to greater emphasis on energy literacy and systems thinking, while also revealing cases where existing curricular structures were perceived as already resilient to disruption.

3. Recommended Curriculum Changes to Better Prepare Students

When asked, “What changes would you recommend in your program’s curriculum to better prepare students?” faculty proposed changes that collectively emphasize resilience under disruption, authentic practice aligned with industry, curricular structures that support adaptability, and explicit training in lifelong learning skills. Preparedness was framed as a combination of mindset (comfort with uncertainty), practice (systems thinking, problem-solving, teamwork), and program design (flexible pathways, proactive planning, and resilient learning infrastructure).

Theme 1 – Resilience, Designed Disruption, and Professional Mindset

Faculty argued that disruption preparedness should be an explicit curricular aim rather than an incidental outcome. They described the need to normalize uncertainty and help students develop tolerance for ambiguity and discomfort as part of professional formation.

“Help students accept the discomfort of disruptions and changes.”
“Instruction about resilience.”

Rather than only teaching about disruption, faculty recommended teaching through disruption by embedding scenario-based shocks into coursework. These proposals included dedicated crisis-management content as well as structured activities where teams must adapt to midstream changes.

“A dedicated class on crisis management seems like a good idea.”
“Add a couple of scenario-based lessons where student teams begin working on a directive, then… significantly change one of the parameters.”
“‘Tower of Babel’, they can no longer vocally communicate with one another, yet must complete their task.”

A set of recommendations also focused on cultivating students’ professional habits: initiative, accountability, and proactive planning that reduces vulnerability to disruption.

“Students (like employees) are responsible for going ‘beyond the job description’… and take the initiative when there are disruptions in learning.”
“Encourage being ahead of schedule in work so delays due to disruptions are minimized.”

Theme 2 – Modern Engineering Practice: Tools, AI Literacy, and Systems Thinking

Faculty recommended curricular updates that better reflect contemporary engineering practice, especially rapid tool evolution and cross-disciplinary problem contexts. Rather than focusing on any one software, they emphasized teaching transferable tool concepts and responsible use, including positioning generative AI as an engineering tool with limitations.

“Current and up-to-date examples in courses, elective courses in new application areas and technologies.”
“Incorporation of new AI tools… (the general type of tool, not specific tools as they change monthly).”
“More training… on ‘systems thinking’ and working in/leading multidisciplinary teams. Acceptance of generative AI as an engineering tool and training on AI's promises and limitations.”
“Engineering should be fundamentally a problem-solving discipline…”

This theme frames modernization not as chasing novelty, but as strengthening students’ capacity to apply concepts across shifting technologies and complex systems and to sustain learning over a career.

Theme 3 – Structure, Infrastructure, and Flexible, Industry-Aligned Pathways

Faculty also recommended program-level supports that make learning more resilient through technology such as remote access and recordings while simultaneously emphasizing governance and instructor control over what is captured and distributed.

“Resources that provide remote access and class recording (these are everywhere now).”
“Mechanisms for recitations online…”
“I would also NOT permit resources like Otter.AI to attend lectures and recitations. The instructor must control what is being recorded and distributed…”
“Not licensing 1 tech.”

Finally, faculty recommended rebalancing curriculum design toward industry-aligned practice while providing instructors and programs with flexible, modular options to adapt content and pathways as disruptions emerge. They emphasized that predictable course organization (e.g., early assignment release and clear syllabi) combined with curricular modularity allows both structure for student planning and flexibility for institutional responsiveness. Importantly, faculty resisted top-down uniformity, arguing that different courses and teaching styles require different formats.

“Make certain that… assignments are made at the start of the semester and included… in the syllabus.”
“Refocus engineering education on industry needs and on professional integrity.”

"College of Engineering should abandon the one-size-fits-all approach and offer an array of options from which the instructor can pick."

Discussion

Engineering faculty characterize disruption as a persistent, multi-layered condition, not a sequence of discrete events, that simultaneously reshapes academic priorities, technological infrastructures, and learning environments, echoing broader accounts of disruption as systemic and multidimensional in higher education (Crawford et al., 2020, Dhawan, 2020). They perceive engineering fundamentals as remaining essential yet increasingly vulnerable, particularly when generative AI and virtual teaching conditions enable students to bypass deep engagement with core concepts. This is a concern that parallels work documenting challenges to rigor and assessment validity during emergency remote teaching (Flaig, 2021). At the same time, some faculty reported minimal long-term skill impact due to significant effort in assessment redesign and remote infrastructure, suggesting that disruption effects depend heavily on institutional readiness and individual faculty capacity (Mok, 2022). This variation raises equity concerns: if preparedness depends on local resources and adaptive capacity, students in under-resourced programs may be systematically disadvantaged.

Beyond fundamentals, faculty identified adaptive, metacognitive, and relational skills as baseline competencies for graduate success in disrupted professional contexts. This aligns with studies that emphasize resilience, adaptability, and communication as key outcomes for engineering education under conditions of uncertainty (Authors et al., 2025; Lindsay et al., 2023). The emphasis on verification and critical judgment of tool outputs reflects recognition that engineering work increasingly involves evaluating AI-generated results rather than producing everything from first principles. This resonates with emerging research on AI literacy that frames critical evaluation of AI outputs as a core professional competency (Johri et al., 2023; Kasneci et al., 2023). Adaptability and continuous learning have become urgent employment readiness requirements, not aspirational career ideals, as tool ecosystems and professional contexts change faster than curriculum cycles, reinforcing calls for curricula that explicitly cultivate lifelong learning and flexible, cross-cutting skills. Field-specific impacts such as increased emphasis on safety and communication in nuclear engineering after Fukushima, or energy literacy and systems thinking in energy transitions demonstrate that disruption reshapes disciplinary practice and values in context-dependent ways and, in turn, informs discipline-specific curricular priorities.

Faculty curricular recommendations reveal a sophisticated understanding of preparedness that extends beyond incremental content updates. They call for explicit resilience instruction, scenario-based pedagogies that deliberately rehearse adaptation under uncertainty, the teaching of generalizable rather than highly specific tool knowledge, and curricular structures that combine predictable organization with modular flexibility. Faculty also position infrastructure and governance choices as part of curriculum effectiveness, resisting single-platform standardization in favor of instructor choice and control, which complicates accounts that portray centralized technological solutions as unequivocally beneficial for educational continuity. For engineering education practice, these findings suggest that curricular preparedness for disruption requires permanent adaptive capacity, sophisticated assessment strategies that distinguish genuine understanding from tool-mediated performance, explicit instruction in metacognitive competencies, faculty development in disruption-rehearsal pedagogies, and distributed decision-making models that enable contextual adaptation rather than top-down standardization.

Conclusion

This qualitative study examined how engineering faculty characterize disruptions affecting their disciplines, perceive impacts on graduate skill requirements, and recommend curricular responses. Drawing on thematic analysis of 13 faculty responses, the findings reveal that disruption is experienced as a persistent, multi-layered condition rather than isolated events, requiring engineering education to shift from preparing students for stable contexts to cultivating capacities for learning and functioning effectively under ongoing uncertainty. Key insights include the tension between protecting engineering fundamentals and enabling adaptive learning, the emergence of verification and metacognitive skills as baseline competencies, and the need for disruption-rehearsal pedagogies combined with curricular flexibility and instructor autonomy. These findings have direct implications for curriculum design, faculty development, assessment strategies, and institutional governance structures in engineering education and complement existing studies that have examined disruption primarily from institutional or student perspectives.

This study has important limitations. The small sample size (13 faculty) and open-ended survey format limit generalizability, and faculty self-reports may not fully capture student experiences or actual skill outcomes. The cross-sectional design provides a snapshot during a particular moment rather than longitudinal tracking of how disruption perceptions and curricular changes evolve. Importantly, because the study centers faculty perspectives, future research should examine disruption experiences from students', engineering professionals', and administrators' viewpoints and track implementation and outcomes of recommended curricular changes across diverse institutional contexts. Despite these limitations, the study contributes timely insights into how engineering educators are thinking about disruption and preparedness at a critical moment when generative AI and other technological shifts are reshaping engineering practice and the expectations placed on engineering graduates, offering empirically grounded guidance for designing curricula that are both conceptually rigorous and adaptable to ongoing change.

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