STUDIES IN ENGINEERING EDUCATION

# Peripheral or Fundamental? Instructor Perspectives on Integrating Societal Content in Engineering Courses

EMPIRICAL RESEARCH

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## ABSTRACT

**Background:** Understanding instructors' perspectives that shape their decision making related to integrating societal content in their courses is key to informing efforts to ensure engineering training prepares students with the skills and knowledge necessary to account for both technical and social dimensions of complex engineering problems.

**Purpose/Hypothesis:** This study examines the varied ways instructors think about the relevance of societal content to engineering courses and how, if at all, it can or should be integrated in their courses.

**Design/Method:** Drawing on interviews with 21 instructors across 11 engineering departments, we leveraged a composite narrative analysis approach to present nuanced descriptions of the narratives articulated by instructors about their decisions related to the integration of societal content in their courses.

**Results:** Our findings describe five composite narratives that highlight a range of perspectives informing instructors' decisions about the integration of societal content, ranging from a belief that societal content has no place in engineering coursework to a belief that societal content is inherent in and a necessary consideration for all engineering work.

**Conclusions:** Instructors' narratives made evident the ways in which technocentric values about engineering work shape decisions about what is taught in engineering courses and how societal content is often weighed against, rather than connected to, technical engineering science content. While many instructors discussed the relevance of societal considerations in engineering, they also described a need for greater support in efforts to implement societal content in their courses.

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## INTRODUCTION

While the field of engineering has long been focused primarily on the technical dimensions of problems and their solutions, the ability to recognize and account for the ways in which engineering work is shaped by and shapes the broader societal context(s) in which it occurs is key in addressing the complex challenges of our modern world (Passow & Passow, 2017; Ro et al., 2015). Contemporary engineering work is inherently sociotechnical, in which social and technical dimensions are equally critical and inextricably interconnected with one another (Reddy et al., 2023). Engineering solutions that do not adequately account for both technical and societal dimensions of a given problem can cause significant harm or, in less serious cases, risk expending the time and resources of all interested parties on solutions that do not work as planned nor provide benefit to the intended users or environments (Daly et al., 2018; Tenner, 1997; Nieusma & Riley, 2010). An emphasis on societal dimensions of engineering is not only key in preparing effective engineers but can also help attract and retain a more diverse engineering workforce (Litchfield & Javernick-Will, 2015; Swan, Paterson, & Bielefeldt, 2014). Prior research suggests that women and those from minoritized racial and ethnic backgrounds—groups who enter and persist in engineering at lower rates—are more frequently motivated to pursue careers in which they perceive a potential for positive social impact (Hughes et al., 2020; Litchfield & Javernick-Will, 2015; McGee & Bentley, 2017; Rulifson & Bielefeldt, 2017; Swan, Paterson, & Bielefeldt, 2014). Engineering training that is inclusive of societal dimensions can help broaden participation in the field and ensure that engineering work is more likely to benefit the people, communities, and environments it impacts.

It is the responsibility of engineering education to support future engineers in developing both deep technical knowledge and the understanding and skills needed to apply this knowledge in a way that accounts for the societal and contextual influences and implications of their work. This need is articulated in ABET's (2021) student outcomes for accreditation, which include:

> *an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors,* and
>
> *an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts*.

However, recognition of the importance of these skills alone is not sufficient to overcome a long history of technical primacy in engineering work and training. Despite calls for greater attention to societal topics in engineering training dating back several decades (e.g., ABET, 1997; ASEE, 2013; Felder & Brent, 2003), significant work remains in how engineering education can best support students' development of relevant skills and knowledge. Research suggests that social and contextual dimensions of engineering work have been consistently underemphasized in the curriculum, often only touched on in a single course or lesson, if at all (Bielefeldt & Canney, 2016; El-Zein et al., 2008; Herkert, 2000). Further, societal content is most commonly taught in project-based introductory or capstone courses at either end of a students' journey rather than integrated throughout the curriculum (Lattuca et al., 2014; Polmear et al., 2019). Supporting students' understanding and ability to account for societal dimensions of engineering work requires more than an isolated intervention (Rodrigues & Seniuk Cicek, 2024). While some instructors may already be integrating societal content in their courses, others may not perceive such content as relevant in their individual course context or need support in identifying and implementing strategies to integrate societal content in their courses.

Given the role instructors play in setting priorities and shaping the curriculum at the individual course and department level, efforts to better support students' development of the skills and knowledge to account for societal dimensions of engineering work must account for engineering instructor perspectives, experiences, and needs related to integrating societal content in their courses. This study aims to contribute to a deeper understanding of how instructors' perspectives

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on the relevance of societal topics in engineering training intersects with practical considerations about their teaching to inform if and how societal content could be integrated in their courses. We drew on interview data with engineering instructors across fields to highlight different ways instructors described their thinking about their decisions related to the integration of societal content. In our analysis, we used a composite narrative approach to highlight five key ways instructors thought about the relevance of societal content to engineering courses and how, if at all, it could or should be integrated in their courses. These composite narratives, grounded in rich detail and context from instructor interviews while maintaining anonymity, can be leveraged to inform decision making around initiatives to support a greater integration of societal content in engineering education.

## BACKGROUND

### CULTURAL PERSPECTIVES ON SOCIETAL DIMENSIONS OF ENGINEERING

Societal dimensions of engineering work have been discussed in the literature in a variety of ways—both in the language used to refer to such dimensions and in the particular skills and understandings emphasized as societal. Within engineering design, for instance, Kilgore and colleagues (2007) characterized a consideration of societal implications as "breadth of problem-scoping, and the context of engineering" (p. 321), exploring the extent to which first-year students considered context-oriented topics such as accessibility, neighborhood characteristics, community input, and safety in approaching design tasks. Ro and colleagues (2015) used the term contextual competence to describe "an engineer's ability to anticipate and understand the constraints and impacts of social, cultural, environmental, political, and other contexts on engineering solutions" (p. 36). A recent literature review by Kleine, Zacharias, and Ozkan (2024) characterized different modes of contextualization present in the engineering education literature: context tools, professional skills, real-world problems, design, social impact, and sociotechnical thinking. Rodrigues and Seniuk Cicek (2024) noted the recent popularity of sociotechnical thinking as a concept in engineering education and characterized the different ways it has been leveraged and operationalized in research. Johnson and colleagues offered a definition of sociotechnical thinking as "the interplay between relevant social and technical factors in the engineering problem definition and solution process" (p. 1) and used the term social to be inclusive of "environmental, ethnical, economic, health, safety, political and cultural factors." Societal dimensions of engineering have also commonly been discussed as central in sustainability (Gutierrez-Bucheli, Kidman, & Reid, 2022), which Watson and colleagues (2017) characterized as including a consideration of social dimensions such as community requests, health and well-being, local circumstances and cultures, and safety. Finally, some scholars have discussed societal dimensions of engineering with an explicit focus on justice, which itself is defined in many ways, but can include a consideration of how engineering work is conducted, by and for who, and how engineering solutions can have disparate impacts on people and communities with different access to resources and power (e.g., Baillie, 2020; Cech, 2013; Riley, 2008). Collectively, these different terms and emphases highlight the broad range of possible ways instructors might conceptualize societal dimensions of engineering and the lenses that may inform how they perceive connections between societal topics and their course content.

Efforts to integrate societal content in engineering training must in many ways counter long-held cultural values about engineering work as a technocentric field, removed from any social or political influences. Dominant framings of engineering work position social dimensions as distinct from, and less valued than, the technical (Faulkner, 2007; Nieusma & Riley, 2010; Niles et al., 2020). Williams (2002) described the entrenched belief that engineering work occupies a distinct technical knowledge domain that can be systematically leveraged to address various technical problems as "the ideology of engineering." Riley (2008) pointed to the influence of positivist epistemology, which characterizes scientific processes of knowing as objective, overlooking the ways in which society shapes scientific work and technologies. The pervasiveness of such beliefs positions societal considerations as irrelevant and/or external to "real" engineering work. Cech

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(2013) argued that this belief that societal considerations are at best tangential to engineering work—which she terms "depoliticization"—as well as the belief that engineering is meritocratic are core to engineering culture and jointly hinder engineering students' awareness and motivation to consider issues of social (in)justice within and attributable to engineering practice. As Niles and colleagues argued, technocentrism "produces a dual effect where, on one hand, it restricts engineers from critically engaging with the social implications of their work; and on the other hand it conceals how engineering is already embedded in social relations" (2020, p. 493).

## SOCIETAL CONTENT IN ENGINEERING COURSES—CURRENT STATE

Recognizing the importance of better supporting students' awareness and abilities to account for the various societal influences and impacts of recent work, there has been a growing effort to integrate more societal content in engineering education and to challenge pervasive technocentric messaging about the work and responsibilities of engineers (Niles et al., 2020). In some instances, programs have integrated societal topics such as ethics or sustainability (which includes societal impacts) through stand-alone lessons or separate courses (Bielefeldt & Canney, 2016; El-Zein et al., 2008; Herkert, 2000). However, these topics might not be seen as valuable or relevant to "real" engineering work if they are presented as distinct from or not reinforced by the rest of the engineering curriculum (Gelles & Lord, 2021). When societal content is integrated into engineering courses, it is most commonly reported in design and project-based courses like engineering introduction and capstone courses (Lattuca et al., 2014; Polmear et al., 2019). The Engineer of 2020 study found that design courses make up a relatively small fraction of the required engineering curriculum but are where faculty most commonly report a curricular emphasis on social and contextual topics (Lattuca et al., 2014).

Compared to engineering design courses, integrating societal content in technically focused engineering science courses can prove to be more challenging (Wood et al., 2024). While there are some notable exceptions, such as efforts stemming from a RED grant at the University of San Diego focused on integrating sociotechnical content in multiple technical engineering courses (e.g., Gelles & Lord, 2021; Chen & Wodin-Schwartz, 2019; Lord, Przestrzelski, & Reddy, 2019; Reddy et al., 2018), societal content is less commonly emphasized in engineering science courses (Polmear et al., 2019). The relative absence of societal content in engineering science courses is notable given the role these courses play in shaping students' understandings of what does, and does not, count as engineering work. Lucena and Leydens argued that engineering science courses have long been considered the foundational element of the engineering curriculum and "play important definitional and normative roles in what an engineer is and what engineering education should be all about" (2015, p. 3). The authors argued that while the engineering science curriculum can and has been contested, any calls for change in these courses face the need to justify re-thinking what have long been unchallenged beliefs about what has been viewed as foundational engineering knowledge. Across course types, the undergraduate curriculum serves as a key vehicle for transmitting messages about disciplinary competencies, interests, and values and providing educational experiences that seek to build these competencies, interests, and values (Lattuca & Stark, 2009). Integration of societal content *throughout* the engineering curriculum would help counter framings of engineering as a strictly technical endeavor, free from any societal influences or impacts (Adams et al., 2011; Claussen et al., 2019).

Changes to the engineering curriculum depend in part on instructors' beliefs and understandings about the relevance of societal content in engineering training. Given the deeply entrenched technocentric framings of engineering work, instructors may encounter particular challenges integrating more societal content in their courses. First, some instructors themselves may have limited exposure to different approaches for linking technical and societal content in their courses (Gelles & Lord, 2021) or feel reluctant to do so without external support in the development and instruction of this content (Nieusma, 2015). Additionally, instructors may worry that including any societal content would require cutting or condensing technical material in already content-dense courses (Hancock & Turner, 2023; Nieusma, 2015). Instructors' perceptions of what is required to meet ABET accreditation criteria or beliefs about what is longstanding "canon" may be of particular concern in making decisions about what content must be covered and what content

may be peripheral (Lucena & Leydens, 2015; Riley, 2011). Concerns about student resistance may serve as another barrier to the integration of societal content in engineering courses. As Lucena and Leydens described, "Some students, particularly the most privileged in class, can display a sense of entitlement, not wanting the class 'they are paying for' to be crowded with 'social stuff'" (2015, p. 13).

Beyond the difficulties of overcoming entrenched disciplinary norms that emphasize the technical aspects of engineering education, instructors also encounter both personal and structural obstacles when adopting new teaching methods and course material (Cheldelin, 2000; Mitchell, Parlamis, & Claiborne, 2015). Integrating new societal content may also require instructors to develop new pedagogical approaches. For instance, engineering education scholars advocate the use of active learning strategies and contextualized real-world examples when integrating societal topics in engineering courses (Gelles & Lord, 2021; Leydens & Lucena, 2018). Developing new lessons demands a significant time investment and instructors may not always be well-supported in implementing new pedagogical approaches that might be required (Shadle et al., 2017; Walczyk, Ramsey, & Xha, 2007). A lack of time and institutional support may impede curricular change efforts (Henderson & Dancy, 2007; Wieman, Perkins, & Gilbert, 2010). As Lattuca and Pollard argued, "In the absence of visible supports faculty are likely to opt out of the change process" (2016, p. 99). Further, faculty reward systems do not always encourage spending time on the creation of new content or refining teaching practices (Matusovich, Paretti, McNair, & Hixon, 2014; Shadle et al., 2017). While previous scholarship provides invaluable insight into instructors' beliefs about the relevance of societal course content and the practical challenges they may face in implementing such content in their courses, it is crucial to explore these two factors jointly in identifying ways to facilitate greater integration of societal content in engineering training and how to connect with and support engineering instructors in efforts to do so.

## METHODS

This study draws on data from interviews with 21 instructors of undergraduate engineering courses across departments at one university to explore the range of perceptions, practical considerations, and experiences related to integrating societal content into their courses. Specifically, we address the following research question:

> *How do instructors describe their thinking about their decisions related to the integration of societal content?*

In our analysis we used a composite narrative approach (Willis, 2019) to identify five key narratives articulated by instructors about how, if at all, societal content might be integrated in their courses.

### POSITIONALITY

Our team is composed of researchers with backgrounds in higher education, engineering, and engineering education. Two members of our team are women, one is a man, and all three are White. All members of our team are affiliated with efforts aimed at facilitating engineering students' development of sociotechnical engineering skills and knowledge, which we define as the ability to recognize and account for the interplay between the technical dimensions and social and contextual dimensions of problems or processes that shape and are shaped by engineering work. Our work includes interventions aimed to support instructors in identifying opportunities for and facilitating lessons on sociotechnical connections in their engineering science and design courses. Our motivation to pursue the current study was informed by our collective belief in the importance of improving engineers' understanding and skills related to societal dimensions of engineering and to explore both current approaches being leveraged by engineering instructors as well as experiences and beliefs that might serve as supports or barriers in including societal content in their courses. Relatedly, our team is sensitive to the inequities that persist in the field of engineering, including those related to who becomes engineers and whose perspectives and needs are prioritized in engineering decision making. Ultimately, we hope to be able to leverage findings from this study to inform future efforts to best connect with and support instructors in

integrating societal content throughout the engineering curriculum. In addition to motivating our research focus, our backgrounds and experiences likely made us particularly sensitive to data that highlighted beliefs or barriers that might serve to inhibit instructors' integration of societal content.

Recognizing the potential sensitivity of instructors' beliefs related to the integration of societal content, our team took care to frame our interview protocol and recruitment language in an open-ended manner that did not overtly favor a particular approach or perspective related to the integration of societal content. The author contacting instructors and conducting the interview was a staff researcher and did not hold a leadership position nor was she affiliated with an academic department in the institution studied. These details, coupled with her framing of the interviews as seeking out the instructors' expertise in their courses and curricular decision making and assurances of anonymity in any reporting, may have served to reduce instructors' potential concerns about sharing beliefs that might not have aligned with what was, at the time, college-wide messaging related to the importance of societal dimensions of engineering work. Conversely, her affiliation with efforts to support greater integration of societal content, in the event that any instructors were aware of this affiliation, may also have informed what instructors shared or how they framed their responses.

## PARTICIPANTS

Participants for this study included 21 instructors in the College of Engineering of a large, predominantly White institution with an R1 Carnegie classification. Focusing on a single institution allowed for a more contextualized analysis, as all participants operated within the same institutional culture, tenure and promotion expectations, and institutional resources, providing a consistent backdrop against which to interpret their varied perspectives of societal content integration. This institution had also engaged in recent campus-wide conversations about societal issues in engineering, making it a particularly relevant case for examining faculty's interpretations and perceptions of the relevance of societal topics in their particular course contexts.

Participating instructors had varying backgrounds, departments, and ranks who regularly taught one or more undergraduate engineering courses. The undergraduate engineering courses taught by these instructors included a range of levels from first-year introductory courses to advanced undergraduate courses typically taken by students in their fourth year. While several instructors described experiences teaching in design courses, the majority taught required engineering science courses and technical electives. Many instructors described their experiences teaching more than one course. These instructors included four lecturers/teaching professors, three assistant professors, six associate professors, and eight full professors. They represented 11 different departments across a single college of engineering. Some participants held appointments in more than one department. While we chose to not explicitly ask about instructors' social identities, we estimate approximately a third of participants were women and a third were people of color, based on instructors' discussion of their identities and presentation during interviews. We intentionally recruited from a pool of participants who had not already been engaging with our team's initiatives to support instructors in their implementation of societal course content, as our focus was on understanding instructors' perspectives on societal content integration more broadly, rather than their feedback on any particular initiative.

Participant recruitment happened in several rounds between Fall 2022 and Spring 2023. First, our team solicited suggestions from our network for instructors across departments and ranks who might hold various beliefs related to societally focused engineering course content. After this round of recruitment, we then reached out to a small number of instructors who had received teaching awards over the last five years. Finally, with an eye toward increasing the range of departments represented in our study, we leveraged a college database of courses to identify instructors who taught undergraduate courses in their departments. One member of our team sent all recruitment emails, explaining our study's focus on instructor decision making about their course content, with a particular focus on how, if at all, they thought about integrating society-related content in their courses. The recruitment message explained that the purpose of our study was strictly to understand their perspectives and experiences, rather than evaluate their teaching or curricular

decision making. Interested participants could sign up for an interview time via a calendar link or reply to the email with their interest and availability. Overall, we sent 97 recruitment emails and completed interviews with 21 of those instructors. We did not decline to interview any instructor who expressed interest in participating.

## DATA COLLECTION

Interviews for this study lasted between 18 and 48 minutes, with most lasting between 30–40 minutes. The majority of the interviews were conducted via Zoom, with only one interview occurring in person due to the instructor's preference. Interview audio was recorded and transcribed using Zoom's software, with the exception of the in-person interview that was audio recorded on the interviewer's phone and transcribed using the Rev.com service. No video recordings of the interview were used for analysis or retained. The researcher who conducted the interviews reviewed all transcripts for accuracy prior to analysis. Instructors did not receive compensation for participating in the interviews.

The interview protocol used in this study was developed by our team through an iterative process. One member of our team developed an initial protocol draft and shared it with members of the research team for review and feedback, refining it accordingly. For instance, based on a team conversation, we updated the protocol to include a question near the end of the interview that named a series of existing faculty supports for adding or changing curricular content and asked instructors to share how useful or motivating they found various approaches. Another key decision in our protocol development process was to leave the meaning of "societal content" open to instructors' interpretation. This decision was grounded in a desire to understand instructors' own interpretations and applications of societal content and invite multiple perspectives, taking an exploratory, rather than prescriptive, approach. In a final round of iteration, the team shared a copy of the protocol with several colleagues, including some with instruction and instructional support experience in engineering, for additional feedback on the focus and wording of questions. Interview questions included items such as:

- In what ways do you think the content of your courses relates to society, however you define it?
- How did you come to integrate society-related content into your course(s)? Were there any particular resources or experiences that you've found useful in developing society-related content?
- What have you found to be the biggest barriers to teaching about society-related content in your course?
- In an ideal world, is there anything you'd like to change about your course related to connections between engineering and society?

After refining our interview protocol and study plans, we submitted these to the University of Michigan's Institutional Review Board and received an approved exempt determination (Ref. #00180685) prior to beginning any data collection.

## DATA ANALYSIS

We leveraged a composite narrative approach (Willis, 2019) in our analysis for this study, drawing on interview data from multiple instructors to create each of the five main narratives around instructors' thinking about their decisions related to the integration of societal content in their courses. The use of composite narratives is a relatively new approach in engineering education research (Sajadi, Kellam, & Brunhaver, 2023). Composite narratives present interview data as if it were from a single individual but draw directly on data from a collection of source interviews. The use of composite narratives offers several key advantages that motivated our use of them in the present study. First, composite narratives can protect the anonymity of individual participants while still being grounded in rich real-world accounts (McElhinney & Kennedy, 2022; Sajadi et

al., 2023; Willis, 2019). Relatedly, composite narratives also allow for complexity and avoid de-personalizing data (McElhinney & Kennedy, 2022; Willis, 2019). Additionally, composite narratives present data in an accessible, relatable manner that can enhance the transferability and impact of research and motivate action (Creese et al., 2021; Johnston, Wildy, & Shand, 2023; Sajadi et al., 2023; Willis, 2019).

Willis (2019) describes four practices to guide the process of developing composite narratives, which we adhered to in our analyses for this study:

1) Each composite is based on interview transcripts, with multiple transcripts condensed into a composite narrative.
2) All quotations are sourced directly from the source interview transcripts.
3) All other details about the participant, their background, or the interview context are taken directly from one of the source interviews.
4) The researcher should avoid imposing on participants' experiences and opinions and should not assume motivations or feelings. Any such comments should be taken directly from the source interviews.

Beyond these four guiding practices, approaches to the development of composite narratives vary based on the data and aims of the research. For instance, while some prefer to develop the narratives as first-person accounts (e.g., Johnston et al., 2023), our team drafted the narratives in the third person, as others have similarly opted to do (e.g., Creese et al., 2021; McElhinney & Kennedy, 2022; Willis, 2019). In our analysis, we allowed for one source interview to be used to inform the development of multiple narratives only if multiple non-contradictory ideas were expressed by a participant, consistent with the approach described by Johnston and colleagues (2023). For example, one instructor's source interview may have been used both to develop the narrative for Instructor D, related to the challenges of navigating the integration of societal content and a desire for support in doing so, as well as the narrative for Instructor E, which articulates a belief in the inherent relevance of societal content to engineering coursework. For each narrative, we drew on between 4 and 10 source interviews, detailed in Figure 1 in the Findings section below. In addition, the instructor details depicted in each narrative, such as department and rank, were drawn from one or more of the source interviews in order to provide additional context, consistent with Willis' (2019) guiding principles described above. Because we did not explicitly collect participating instructors' social identities, we did not include these details and use the singular form of they in each composite narrative.

To develop the narratives described in this study, the lead author engaged in an iterative process of analysis, guided by the practices outlined by Willis (2019). She first read the source interviews multiple times, noting key themes that emerged and discussing these with other members of the team. Then, guided by these emergent themes, she began to organize all relevant data in a single document, summarizing details of each participant's background and articulated beliefs under the relevant theme, along with relevant excerpts from each interview. In conversation with other team members, she refined and reorganized the groupings of themes, eventually drafting summary statements of the emergent narrative from each thematic grouping. Finally, drawing on real details from the source interviews and relying heavily on the use of quotes from these interviews, she drafted each composite narrative presented below.

## LIMITATIONS

There are several limitations of this research that merit consideration in interpreting our findings. First, our sample, intentionally drawn from instructors across a range of backgrounds and disciplines, does not allow for an in-depth understanding of instructor perspectives from any one group. While it was our aim to explore a wide range of perspectives, this approach may obscure patterns in instructors' thinking about societal content integration based on their affiliation with a particular engineering field or identification with any other professional or sociodemographic group. It is possible, for instance, that lecturers focused primarily on teaching might have different perspectives than tenured

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research-oriented faculty. Our data did not allow for identifying these types of patterns. Relatedly, our decision to not explicitly ask instructors about or report on their social identities precluded any analysis related to patterns in societal emphasis associated with these identities. Though prior research points to patterns in engineers' relative emphasis on social impact associated with social identities, such an analysis is outside the scope of the present study's methodological affordances and focus. Additionally, our decision to leave the definition of societal content open to instructors' own interpretation could mean responses were more likely to touch on societal dimensions that were particularly salient in the particular cultural and political context, such as considerations of diversity, equity, and inclusion. Finally, our sampling approach, relying first on recommendations from our network and later broad outreach with participants opting into the study, may mean that those instructors represented in our sample hold different views than their peers at large. For example, those instructors who either already felt more positively about societal content integration or who were already implementing societal content in their own courses might have been more willing to participate than those who felt more ambivalence about societal course content.

## FINDINGS

Our findings include five emergent composite narratives that represent a wide range of instructors' perspectives about the relevance of societal content to engineering courses and their decisions about how, if at all, societal content can or should be integrated in their courses. As shown in Figure 1, these narratives are presented in approximate order of the degree of openness they articulate related to the integration of societal course content. Each narrative draws directly from interview data with multiple instructors, synthesizing these data into a single narrative that aims to highlight the nuance of instructors' discussions of their experiences and reasoning while preserving the anonymity of individual instructors. Figure 1 lists the interviews that informed each composite narrative as either a source of direct quotes included in the narrative or through alignment with one or more of the themes described.

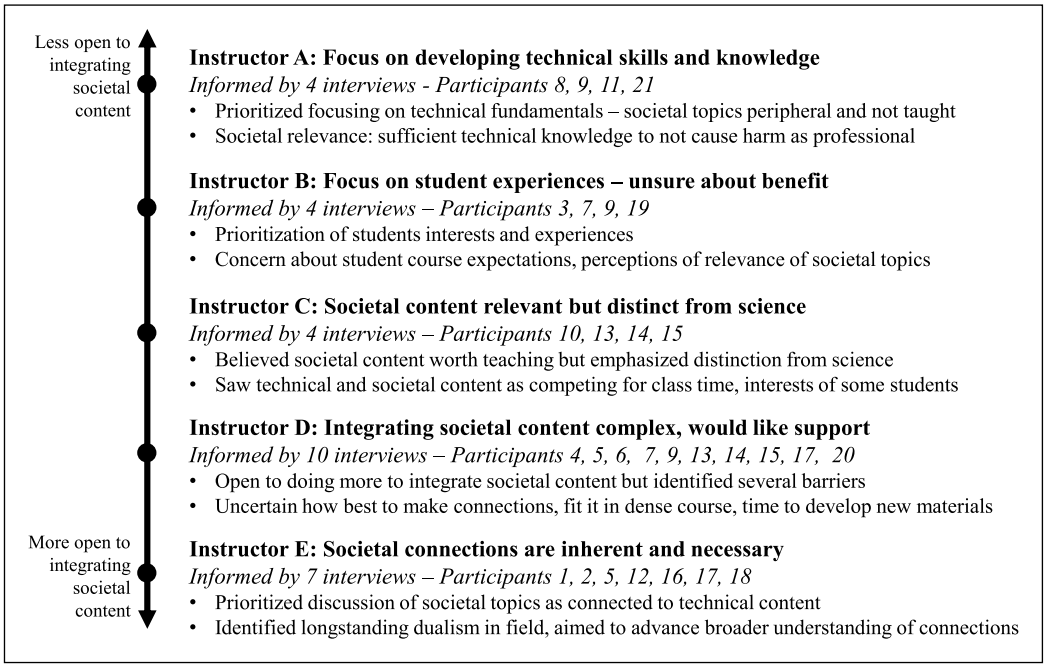


**Figure 1** Narratives related to integration of societal content and count of source interviews.

### INSTRUCTOR A: THE FOCUS OF UNDERGRADUATE ENGINEERING COURSES SHOULD BE DEVELOPING STUDENTS' TECHNICAL SKILLS AND KNOWLEDGE—THE SOCIETAL IMPACT IS PREPARING STUDENTS TO BE TECHNICALLY COMPETENT ENGINEERS

Instructor A was an associate professor in Nuclear Engineering. They described the undergraduate courses they taught as "fundamental courses," focused almost entirely on foundational technical and theoretical principles. Their primary goal was to provide students with a strong technical

understanding, explaining "the main thing I am concerned with is for the students to take away is the technical content."

When asked about any societal connections of their course content, they described the connection as "very indirect," elaborating that "now, if you teach the technology, the science will certainly have impact on the society, but not directly, but the students need to understand [the technological foundations] before they can work." Instructor A argued that a technical foundation was crucial to any future work their students might engage in and explained that if students "don't understand those fundamentals, or how to apply the fundamentals, there's not much they can do that's going to be useful to anybody." They described a sense of responsibility in providing students with the technical skills and knowledge prior to the start of their professional careers, asking "am I teaching them as much as possible of the things that they would need to know once they get out and they get in the profession, and they and they work as engineers?" They concluded "that's how I see it related to society, because, whatever we do, whatever they will do, it's going to be affecting the society."

Instructor A did not express an interest in adding any societally related content in their undergraduate courses, explaining potentially "political" content felt far removed from the course content or "not even in the orbit of the class." While they described connections between societal content and the work of engineers in his field broadly and even to their own research, they did not see a need to discuss those connections in his courses, explaining "I sort of think those [societal] relationships are obvious enough that we don't talk about them. They [students] know, they live in this world." Further, Instructor A explained that they were "not sure I would feel comfortable" raising their "own personal opinion about the implications of the theory." Finally, Instructor A expressed a concern that introducing "peripheral material" related to societal connections "takes away from the time to cover the fundamentals."

## INSTRUCTOR B: MY FOCUS IS ON MY STUDENTS' EXPERIENCES AND LEARNING AND I'M NOT SURE SOCIETAL CONTENT WOULD BENEFIT THEM

Instructor B was a lecturer in Computer Science Engineering. They expressed a deep concern for their students' experiences and learning in the courses they taught. While they were not strictly opposed to the idea of integrating societal content in their undergraduate courses, their first priority was ensuring students had a positive experience in the course and felt the material covered was useful, explaining they felt a "very profound sense of responsibility to make sure that they get the skills." They expressed concern that students who enrolled in technical engineering courses would not appreciate the "academic relevance" of societally related content, explaining that students took "the technical classes, presumably because they're interested in learning about the technical content. I think what I would worry about is, you know, even if we say, Okay, here's an entire lecture on inclusivity [...]Even if it's an important topic, if they are not interested in the topic, because it can't be tied to any of the context that they're actually interested in being here, or, in the first place, it's not going to be particularly effective."

In addition to concerns about students' interest and perceptions of relevance of societal content, Instructor B described potential "trade-offs" and that integrating societal content might mean "not providing something that would be useful technical background." They wondered if integrating societal content in their courses might create "more work" or "overwhelm" students. They elaborated, stating:

> *To add more learning, objectives, and goals would be really unfair, I think, to our student core. We also want to develop interest in our students without, you know, sort of like alienating them [...] if they sign up for a class for a reason, we are delivering on those goals as well as sort of like embellishing it with all of these other things that we believe to be important*.

When asked about the possibility of integrating additional societal content in the future, their responses echoed a prioritization of how doing so could affect students, stating "we have to really figure out best practices of how to integrate this [...] There is fairness to everything that we want to

address." Further, they added that having evidence of the benefits of integrating societal content could be a motivating factor in making such a change to their course. They explained that "some kind of prior evaluation that says these are useful things to do and [...] actually led to students being far more aware" would help them feel more confident in integrating societal content in light of potential trade-offs.

## INSTRUCTOR C: SOCIETAL CONNECTIONS ARE RELEVANT IN ENGINEERING, BUT THESE ARE DISTINCT FROM ENGINEERING SCIENCE

Instructor C was an associate professor in the Aerospace Engineering department. They described a belief in the importance of developing students' awareness of the societal connections and impacts of their work but made a careful distinction between the engineering science and any societal impacts or decisions that were informed by this science. When asked about the societal connections of their course content, they expressed their belief in the importance of these topics, explaining "engineering should be about creating solutions like to help advance things largely driven by like society and human needs." However, they expressed concern about coming across as "a partisan actor" and expressed fears that by not distinguishing between science and societal pieces when discussing them they might alienate or receive pushback from students. They explained their approach as follows:

> *I often very much try to present the science stuff from the basis of the history of how it is learned [...] and try to clearly delineate between the science and the societal decision making. And part of the challenge with [course topic] is that those things often get meshed together, and those things are separate things. There's what we know about science, and then there's what do we decide that we want to do about it?*

Instructor C also made a distinction between the focus of engineering science and design courses, explaining that in design courses there are more opportunities to discuss "things like the regulatory structure and ethical code," contrasting these with the "much more kind of traditional engineering science learning objectives" outside of design courses. However, even within design courses they made the distinction between science and societal considerations.

In discussing their reasoning for their approach to teaching, Instructor C described a number of dynamics shaping their thinking. First, they raised a concern that including societal topics in more engineering science-focused courses represented "a distinct divergence away from whatever topic I'm talking about [...] so the signaling of like, this is its own thing." Second, they noted that challenge of finding time in their course due to "competing learning objectives" and "the tyranny of how much you really on the science side need to get the students to understand," explaining that it was then "the [learning objectives] that are, you know, quote, 'the softer ones'" that "get lost in the shuffle."

Instructor C perceived many students to have relatively dualistic engineering interests, with some more drawn to technical dimensions of the work while others are more interested in societal dimensions. They shared that, in their experience, many students gravitate to either more "dry science, dry engineering" or "the societal impact stuff." Further, they felt that some students with societal engineering interests were less motivated to learn about technical course content. They explained that "there can be reluctance" towards the technical scientific content "amongst the students that want the societal impact stuff, because they're kind of impatient for it."

## INSTRUCTOR D: INTEGRATING SOCIETAL CONTENT COULD BE IMPORTANT BUT DOING SO IS COMPLEX AND THERE ARE BARRIERS THAT I AM UNSURE I CAN ADDRESS ON MY OWN

Instructor D was an assistant professor in Industrial Engineering who described an openness to doing more to integrate societal content in their undergraduate engineering courses but spoke of the complexities in doing so. While they explained that, currently, they will "toss in like 2 minutes" of societally related content based on real-world examples in a class, there are a number of barriers to doing more that are difficult to address without additional support. They perceived

that their students "care so deeply about" societal topics and that students "would totally eat up" additional societally focused content but cautioned "it would have to be well done."

Instructor D identified their own experience and comfort making "the loose connections from Point A to Point B," referring to societal and more technical course content, as a key barrier. They explained, "I don't know how to bring that into my courses yet, because I just don't have enough knowledge myself." They felt that integrating societal content related to matters of identity or climate might be particularly difficult, elaborating "it would make me feel much less comfortable to guide a conversation in a classroom about topics that are less technical and more related to say diversity and inclusion." Further, they described the relative "ambiguity" and complexity of societal topics as a challenge for teaching students modeling skills, noting "if somebody takes like a big societal problem like climate change or poverty– it's just hard to quantify a model that's much more open-ended." They explained that, compared to the complexities of societal examples, problems more narrowly focused on maximizing efficiency or profits in a contained industry setting were often easier examples to use to model technical concepts.

Another key barrier to integrating societal content Instructor D named was the already content-dense curriculum. They explained, "There's perhaps not enough time already in the lectures to cover everything that we want in terms of technical content" and asked, "What am I gonna cut out of the course to make space?" to integrate any societal content. They concluded, "The undergrad curriculum is packed."

Instructor D also noted barriers related to the time and effort required to substantially rework a course as an additional factor that shaped their ability to integrate additional societal content into their courses. They explained that "it's 10 hours of prep for every new hour of lecture, you know, you just need to find that time from somewhere." They suggested that having support in the preparation of content could help address this challenge, explaining "like if somebody else did the work for me, right, that'd be fine." They also expressed a desire for a bank of societally focused examples related to the content in their field that was "easily searchable and found and free to use without any copyright problems." They explained that this bank of examples would allow instructors to build on those resources to integrate additional societal content into their own courses.

## INSTRUCTOR E: SOCIETAL CONNECTIONS ARE INHERENT IN ENGINEERING WORK AND INTEGRATING SOCIETAL CONTENT IS A NECESSARY ASPECT OF ENGINEERING TRAINING

Instructor E was a full professor in Civil Engineering who felt that societal considerations were inherently linked to the technical dimensions of engineering work in their field and expressed a firm belief in the importance of making evident these connections in their teaching. They explained that while "there are a lot of technical details" and "math and physics" in their courses, "what we are trying to discuss always [...] is to connect with policy." They cited climate change as a key means for connecting technical and societal content in their courses and described course goals related to developing students' ability to "translate physical [...] science to community level adaptation and mitigation plans," "learn how to engage with the community," and start thinking about problems "as a system." They noted that students' "tendency as engineers is to come at it looking at it from a very, very narrow perspective" and discussed their goals to help students consider broader societal connections in their work.

In part, Instructor E felt that the focus of the field and their courses leant itself to a focus on societal topics because it is "a lot more socially relevant" than some other engineering topics, elaborating: "We're kind of unique because of the civil engineering field. The word civil just implies that whatever we do affects civilian populations. And so, yeah, I think the interaction with society happens naturally." They noted barriers to broader integration of societal content within engineering related to instructors' own training and cultural beliefs about valued forms of engineering work, explaining:

> *Traditionally scientists and engineers are trained in the technical portions of the field, and I think that most of them probably feel pretty uncomfortable teaching something out of*

*their field; There's also a tendency in academia to create these hierarchies in which pure, more technical research is considered at the top, and the more applied you go, the less credibility credits are given.*

Instructor E expressed support for greater integration of societal content in the curriculum but explained that, in order for such curricular change efforts to be effective, "there needs to be structural support and sort of vocal structural support for these initiatives." In particular, they spoke of the importance of greater consideration of equity in engineering course content, explaining "any time we talk about society, you have to center marginalized communities." They argued that efforts to support students' development of greater awareness of societal impacts of engineering, and considerations of equity more specifically, should be a "part of the curriculum at every level." They explained that "if you think of it as being important, then it should be just as important as your ability to do various technical objectives," and argued for the importance of linking societal content to existing technical course content.

## DISCUSSION

The five instructor narratives detailed in this study articulate a wide range of perspectives related to the integration of societal content in engineering courses and highlight several cross-cutting themes about the ways in which instructors' perceptions of the relevance of societal topics *and* a range of practical considerations and structural factors serve to hinder or support such integration. Some engineering instructors, represented in the narrative of Instructor A, felt strongly that, while engineering work in the professional world might have societal impacts, it was not the role of undergraduate engineering training to teach about societal dimensions of engineering. Rather, these instructors felt the primary focus of engineering training should be preparing students with the technical skills and knowledge they viewed as the fundamentals of engineering practice. This orientation toward societal course content is a stark contrast to the perspective represented in the narrative of Instructor E, which characterized societal content as equally central to engineering work and training as technical content and expressed a goal of helping students understand the many linkages between social and technical dimensions of their work. While Instructors A and E represent opposite ends of the spectrum of perspectives represented in the present study, narratives for Instructors B, C, and D expressed various nuances in instructors' consideration of if and how societal content can and should be integrated in engineering. For instance, Instructors E and C both spoke to the importance of societal content in engineering courses, but instructor C ultimately concluded that it was necessary to delineate between societal and technical dimensions in their course implementations. Relatedly, the fact that several participants' interviews were used to inform multiple narratives reflects the complexity of instructors' thinking about societal content integration. In one example an instructor both described reluctance based on how societal content might be perceived by students and described structural barriers that, if addressed, could ultimately facilitate their integration of societal content. The narrative for Instructor D was drawn from the highest number of source interviews (10), including several source interviews also leveraged in other narratives. Instructor D represented the challenge instructors may face in integrating societal content in their courses, even if they perceive it to be important, articulating the uncertainty in how to effectively integrate societal content and the structural barriers instructors might face in making changes to their course content and instruction.

As described in detail in this section below, while the five instructor narratives represent different perspectives, considerations, and priorities about if and how engineering courses might integrate societal topics, across narratives several themes are evident: a) the persistence of technocentric, dualistic beliefs about engineering work; b) how societal content is more easily integrated into certain course types and foci; and c) the barriers instructors face in integrating societal content, regardless of their beliefs about its importance. Taken together, these narratives deepen our understanding of how instructors navigate the integration of societal content in engineering education, illuminating the complex combination of personal beliefs, structural conditions, and pedagogical priorities that shape curricular decisions.

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Instructor narratives around their thinking about if and how to integrate societal content in their courses highlight the persistence of technocentric beliefs about engineering work. While there were some instructors who expressed perceptions of societal dimensions of engineering work as equally important and inextricable from technical dimensions (most closely represented in Narrative E), the majority of narratives belied dualistic framings of the technical and social aspects of engineering work well-documented in prior research (e.g., Faulkner, 2007; Nieusma & Riley, 2010; Niles et al., 2020). As highlighted in Instructor C's narrative, even some instructors who spoke to the importance of including societal content in their courses described making clear the distinction between science and societal dimensions of engineering or used language contrasting "dry engineering" with "soft" "social impact stuff." This finding echoes Cech's (2013) discussion of depoliticization as a pillar of engineering cultural beliefs in which engineering's claim to legitimacy for much of its history relies on the perceptions that engineers are able to isolate any social or political influences from the technical decision-making work of the field. A depoliticization narrative was particularly evident from those instructors who argued that engineering training should be strictly technical, focused on the "fundamentals" of engineering, a framing that aligns with Lucena and Leydens' (2015) discussion of the ways engineering science has long served to define engineering work. These instructors described the primary societal connection of their courses as the long-term impact of preparing students adequately with technical skills and characterized societal course content as too "political" or merely "personal opinions." This framing suggests that the potential for beneficial or harmful impacts of engineering work lies primarily in technical accuracy, overlooking both the consequences of failing to adequately account for societal dimensions and impacts and the ways engineering work is itself shaped by societal forces. Notably, some instructors cited a concern for their students' reactions to any content that deviated from the "standard" strictly technical engineering science content as a factor contributing to their hesitation to highlight societal connections in their courses. While prior research has documented these technocentric and depoliticized orientations among students and in engineering culture more broadly, this study extends that literature by illustrating how such beliefs manifest in instructors' own curricular reasoning and classroom decision-making, even among those who value societal aspects in engineering. A narrowly technical focus of engineering training may not prepare students in a way aligned with ABET's (2021) requirements, which include the ability to "consider the impact of engineering solutions in global, economic, environmental, and societal contexts."

Across narratives, our findings also suggest that instructors felt certain course types or foci, and certain societal topics, were better aligned with goals of societal course content integration than others. For instance, consistent with data on societal content across course types (Lattuca et al., 2014; Polmear et al., 2019), some instructors, including some represented in the narrative of Instructor E, discussed their beliefs that societal content fit more naturally in design-focused courses than engineering science courses. Similarly, instructors most commonly named natural linkages to societal topics when touching on topics of climate, infrastructure, and sustainability. While there are some models for integration of societal topics in less applied engineering science courses (e.g., Gelles & Lord, 2021; Chen & Wodin-Schwartz, 2019; Lord, Przestrzelski, & Reddy, 2019; Reddy et al., 2018), societal content represents a significant departure from the norm in these courses (Lucenda & Leydens, 2015). Looking to successful examples of strategies make connections to societal content, even in small ways, throughout the curriculum is key to supporting students' understanding of the sociotechnical nature of engineering (Adams et al., 2011; Claussen et al., 2019), and may be particularly important in engineering science courses, given the role they play in shaping what is perceived to be fundamental engineering knowledge (Leydens & Lucena, 2018; Lucena & Leydens, 2015).

Instructors' recognition of opportunities to integrate societal content in their courses may also relate to their personal interpretation of the specific scope and scale of what societal content entails. Some instructors who expressed reservations about societal course content in their class tended to implicitly define societal topics as addressing large-scale challenges like climate change and gender and racial inequality. The salience of these topics may in part have been informed by conversations happening nationally and locally at the time of the interviews. Undoubtedly there

are countless examples of the ways topics like climate change and gender and racial inequality are critical in engineering training and work (e.g., Carter, Razo Dueñas, & Mendoza, 2019; Faulkner, 2007; Martin et al., 2022; Milovanovic, Shealy, & Godwin, 2022); supporting instructors' recognition of how societal topics might also connect to the work of their courses at a smaller scale could help some instructors build comfort. Rather than an assumption that integrating societal content means tackling all of a massive and complex topic like climate change, introducing a homework problem in which students calculate the energy requirements of a given product and consider trade-offs in how that energy may be sourced or generated may feel significantly more achievable.

Finally, our findings across narratives suggest that, even for those who perceive societal topics to be relevant to their courses, many instructors face barriers in actually implementing any such content. Consistent with previous research (e.g., Shadle et al., 2017; Walczyk, Ramsey, & Xha, 2007) documenting the effort and support needed to implement curricular change, instructors cited concerns about the time required to develop new content or difficulties finding or identifying appropriate content. In addition, some instructors spoke to a sense of vulnerability particular to facilitating conversations about societal content, expressing doubts about their own expertise on societal topics and the challenges of navigating more "ambiguous" or potentially sensitive course discussions. The potential vulnerability in integrating new content might be exacerbated by reward structures that do not encourage, and at worst penalize, the effort and risk associated with developing and teaching new content that may push on the boundaries of traditional conceptions of engineering work. Echoing themes documented in the literature about the role of structural supports and reward systems (e.g., Lattuca & Pollard, 2016; Matusovich, Paretti, McNair, & Hixon, 2014; Shadle et al., 2017), instructors described the need for more structural support of societal content integration.

## IMPLICATIONS FOR EDUCATION AND RESEARCH

Our findings point toward several implications for both education and future research. First, they highlight the need for greater visibility of the ways engineering work is influenced by the social context in which it is situated. Consistent with Riley's (2008) discussion of the role of positivism in masking the ways engineering work itself is shaped by the cultural context in which it is embedded, several instructors spoke about the impacts that engineering work might have on society (particularly the potential negative impacts of engineering failures) but espoused beliefs that engineering work was or should be free of any social or political influence. Similarly, other instructors expressed concerns that their students might not perceive the academic relevance of any societal content. Integrating societal course content requires first supporting instructors and future instructors in developing the understanding and language needed to discuss points of connection between technical and societal dimensions of engineering problems in their particular domain. Lessons about engineering history, examples of societal impacts of contemporary engineering problem solving, or an introductory science and technology studies mini course early in engineers' academic journey could highlight some of the ways that engineering work is defined, scoped, and conducted are shaped by the cultural context in which it is situated. The aim of such strategies would not be to change what engineering work is, but rather to support recognition that engineering practice is inherently sociotechnical and shapes and is shaped by the larger societal context—whether these impacts are acknowledged and accounted for or not (Cech, 2013; Faulkner, 2007; McGowan & Bell, 2020; Rodrigues & Seniuk Cicek, 2024; Trevelyan, 2010).

Relatedly, engineering instructors in our study articulated how they could benefit from external resources and support in identifying opportunities and strategies for integrating societal content in their courses. Several instructors expressed an openness to doing more to integrate societal content in their courses but cited challenges such as uncertainty in how the particular technical focus of their course might lend itself to societal connections, a lack of time to develop new content, or questions about the best approaches for facilitating conversations of societal topics with their students. Having resources that enabled instructors to partner with instructional developers or others with expertise in identifying and facilitating discussions of societal linkages

to engineering work (e.g., Cameratti-Baeza, Mosyjowski, & Daly, 2024) could help reduce some of the barriers to this integration. Other potentially useful resources include a repository of real-world examples of societal/technical connections organized by discipline or means for instructors to share strategies and content with their peers across institutions. Prior research suggests that supporting opportunities for instructors to connect with and learn from colleagues is a powerful tool in supporting curricular changes (Austin, 2011; Wenger, McDermott, & Snyder, 2002; Gehrke & Kezar, 2017).

Findings from this study also have implications for scholarship, making evident the need for additional research on the effectiveness of particular strategies for integrating societal content in engineering and the impacts on student experiences and learning of societal integration more generally. Several instructors named a desire for empirical evidence of the outcomes associated with particular strategies or questions about the documented impacts of societal content integration broadly on students' learning as contributing to their decision making around their course content. Making changes to curricula is a resource- and effort-intensive process and (existing and future) research on the benefits of integrating societal content in engineering courses and the efficacy of particular integration strategies can help justify these efforts. Sharing data with instructors has been shown to provide instructors with a sense of agency in and support their continued engagement with curricular change efforts (Henderson et al., 2011; Ngai et al., 2020; Quan et al., 2019). Strategies to make existing research on societal content integration more visible and accessible to instructors and support for additional research on approaches to integrating this content across contexts could support broader awareness and classroom implementation.

## CONCLUSION

Motivated by the need to better train future engineers to account for both the technical and societal dimensions of contemporary engineering practice, this study explored instructors' perspectives that informed their decisions on how, if at all, to integrate societal content in undergraduate engineering courses. Drawing on data from interviews with 21 instructors across engineering departments, we developed five composite narratives highlighting a range of perspectives that shaped these instructors' curricular decision making. Narratives included perspectives such as: a) while engineering solutions have societal impact, engineering training should focus strictly on technical content; b) students are a priority and it is unclear if societal content would benefit them; c) a consideration of societal connections is important but is distinct from technical dimensions; d) successful integration of societal content would require support; and e) societal and technical dimensions are both important to teach and inextricable from one another. These findings provide insight into how different engineering instructors might approach decisions to teach societal engineering content and highlight the ways that both entrenched cultural beliefs about the technocentric nature of "real" engineering work and systemic barriers and pedagogical considerations serve as a barrier for imagining and implementing ways to integrate societal and technical considerations in training future engineers. Understanding the joint influence of instructors' beliefs and the barriers and supports they identified is a crucial foundation for implementing actionable strategies tailored to instructor needs in order to support broader integration of societal content in engineering and ultimately improve the preparation of future engineers to tackle the complex sociotechnical challenges of modern engineering work.

## REPRODUCIBILITY

Due to the identifiable and context-specific nature of the participant interviews and in keeping with the terms articulated in our informed consent document, the authors have not chosen to publicly share the interview data used in this study. Individual clarifications or other inquiries are welcome and can be directed to the corresponding author.

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## COMPETING INTERESTS

The authors have no competing interests to declare.

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