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Exploring Evidence of Student Support Regarding Integration of Sociotechnical Content into Engineering Coursework

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Abstract

Integrating sociotechnical content into technical coursework has emerged as a promising approach for emphasizing ethical responsibility and social impact. While prior research has documented both benefits and concerns, including anticipated student resistance, there remains a need to better understand how students perceive such integration across different institutional contexts. This study explores student support for sociotechnical integration through the implementation of four instructional modules embedded within introductory circuits courses at two universities in the USA: a large public university and a small private university. Using a mixed-methods approach, we analyzed exit ticket survey responses (n = 105) and conducted semi-structured interviews with twelve undergraduate engineering students. Quantitative results indicate consistently strong student interest in additional sociotechnical content. Qualitative findings reveal that students valued the modules for broadening their understanding of engineering practice, contextualizing technical material, and reinforcing or clarifying their views on engineer's social responsibilities. Overall, this study provides evidence that students across institutional settings support the inclusion of sociotechnical perspectives in technical engineering courses and perceive such integration as relevant, engaging, and beneficial for their professional development.

Introduction

Efforts to incorporate ethics education into engineering are an important area of research [1, 2]. Ethics education prepares students for the work they will do in industry after graduation and can establish a norm to be proactive about ethical responsibility [2]. Incorporating ethics education into the curriculum is also required by accreditation bodies like ABET [3].

While the need for teaching ethical content in engineering is well-established, several barriers contribute to the limited implementation of ethics instruction. These barriers include limited institutional resources and support for ethics teaching [2], the prioritization of technical content over ethical considerations [4], and overcrowding in the engineering curriculum, which makes it difficult to identify where to add ethics content [5]. Additionally, teaching ethics can be demanding of faculty whose expertise lies in the technical domain [6].

There are many ways ethics has been taught to engineering students, including semester-long ethics courses [7] and integration of sociotechnical content into technical engineering coursework. Sociotechnical integration emphasizes ongoing, iterative engagement between technical and social aspects in engineering decision-making. At the conceptual level, sociotechnical integration rejects the idea of technical-social dualism [8], which states that "social" and "technical" are separate components of engineering work, instead understanding them as intertwined aspects that must be considered together throughout the design and implementation process [8, 9]. Some benefits of using sociotechnical integration include mitigating curriculum overcrowding [5], improving student interest and learning [10], and increasing the participation of minoritized students in engineering [11]. Challenges for integrating sociotechnical content into engineering courses include risks of content dilution and the need for faculty negotiation [5], as well as anticipated student resistance [12].

Research has demonstrated that most students who were presented with one-hour modules on sociotechnical issues integrated into an Introduction to Circuits course perceived the modules as relevant, valuable, and important in technical courses [13]. However, there was some variation in student responses, with a subset stating that technical courses should remain purely technical [13]. Building on this prior work, the present study examines the implementation of sociotechnical modules in the Introduction to Circuits course across multiple institutions, investigating whether students value and seek further engagement with sociotechnical aspects of engineering.

Methods

In this study, sociotechnical integration was accomplished through several instructional modules embedded within the undergraduate introductory circuits courses. The circuits course is one of the first technical courses students take, so the modules signaled the importance of sociotechnical considerations to engineering practice early in the curriculum. The modules each link core technical content to broader sociotechnical issues relevant to the course.

Research Questions

This paper explores the following research question: *How does participation in sociotechnical modules in an introductory circuits course influence students' desire to see more sociotechnical content in their engineering content, and their perception of the importance of sociotechnical content in engineering courses?*

The Modules

For this paper, we study four sociotechnical modules designed by a cohort of seven graduate engineering students participating in the Sociotechnical Engineering Education Scholars (SEES) program [14]. The graduate students worked collaboratively with mentorship from three faculty members to develop content to integrate technical circuits content with broader sociotechnical considerations [14].

1. The **Energy Burden** module introduces students to the fundamentals of power and energy, the real-world costs associated with energy use, and the social impacts of the energy burden (the percentage of income a household spends on energy). It also highlights practical actions that engineers, policymakers, and consumers can take to make energy systems more equitable and affordable.

2. The **Prioritizing Power** module examines the importance of reliable power, especially in healthcare settings. It considers the causes and consequences of power outages, and the role engineers play in maintaining resilient electrical systems. Students apply these ideas in a load-shedding simulation, debating which hospital wards (such as obstetrics, operating rooms, or neonatal care) should retain power during shortages.

3. The **Conflict Minerals** module focuses on the ethical and global implications of mineral sourcing. It explains how everyday technologies like cell phones depend on materials

such as tantalum, which are frequently mined in regions experiencing armed conflict. Using the Democratic Republic of the Congo as a key example, the module illustrates how the US demand for these minerals can fuel violence by contributing to the financing of war. This module also includes a group assignment in which students researched and presented on the conflict-mineral policies of major technology companies, such as Apple, IBM, Intel, and Samsung.

4. The **Energy Efficiency** module focuses on understanding and promoting efficient energy use. It introduces students to United Nations Sustainable Development Goal (SDG) 7 [15], which emphasizes access to affordable, reliable, sustainable, and modern energy for all. The module covers the concept of energy efficiency, explores real-world examples, and examines policy approaches to improve efficiency. To connect concepts to practical outcomes, it includes a hands-on calculation that estimated the energy savings from replacing incandescent streetlights with light emitting diodes (LEDs) in Philadelphia.

During the Spring 2025 semester, the Energy Burden, Prioritizing Power, Conflict Minerals, and Energy Efficiency, modules were implemented at two different universities (Table 1). At a large public university (University A), an assistant professor in electrical engineering facilitated the Energy Burden and Prioritizing Power modules in a course with 53 students. In the same semester, a professor of integrated engineering at a small private university (University B) facilitated the Prioritizing Power, Conflict Minerals, and Energy Efficiency modules in a course with seven students.

Table 1: Module Implementation Details

Module	**University A**	**University B**
Energy Burden	✓ (Week 1)	
Prioritizing Power	✓ (Week 3)	✓ (Week 13)
Conflict Minerals		✓ (Week 7)
Energy Efficiency		✓ (Week 13)

<u>*Data collection*</u>

To answer our research questions, we administered a brief exit ticket survey at the conclusion of each class session in which the Energy Burden, Prioritizing Power, and Energy Efficiency modules were presented. Exit ticket data was not collected for the Conflict Minerals module. We also conducted individual interviews at the end of the Spring 2025 semester.

Exit Tickets

At the end of each class session in which the Energy Burden, Prioritizing Power, and Energy Efficiency modules were presented, students completed an exit-ticket survey to provide immediate quantitative feedback. For this study, we analyzed responses to one of the 7-point Likert-scale items in the exit ticket: *"I would like to have more opportunities to learn about sociotechnical aspects of engineering in this course."* 105 students responded (53 for the Energy Burden module, 47 for the Prioritizing Power module, and 5 for the Energy Efficiency module), with their responses ranging from 1 (*Strongly Disagree)* to 7 (*Strongly Agree*). Note: the 53 enrolled students at University A were invited to complete the exit ticket after each of the two modules, and the five students at University B were invited to do so after one module, resulting in a total of 105 survey responses collected across all modules.

Individual Interviews

At the end of the semester, we recruited students at both universities who had participated in the modules to share their perspectives and experiences through semi-structured individual interviews. The interviews allowed us to gather student feedback on the modules' design and delivery and to explore student perspectives on sociotechnical content in engineering more broadly. They also allowed us to contextualize patterns that emerged from the exit ticket surveys.

Using language we drafted, the course instructor distributed an email invitation to all enrolled students. The same recruitment language was used across all participating institutions. Twelve undergraduate engineering students participated in interviews with nine from University A, and three from University B (see Table 2). In the interviews, students were asked to reflect on each module specifically and on the inclusion of social issues in engineering and engineers' social responsibilities more broadly. This study focuses on student responses to questions addressing students' views on integrating social issues in technical engineering courses. Interviews were conducted over Zoom, recorded, and transcribed verbatim before analysis. Students received a monetary incentive for their participation.

Table 2: Participant Demographics

Pseudonym	**Institution**	**Year in School**
Amar	A	1
Liam	A	1
Molly	A	1
Noah	A	1
Brendan	A	2
Ishaan	A	2
Ivan	A	2
Niko	A	2
Quinn	A	2
Nia	B	3
Talia	B	3
Will	B	3

Data analysis

To analyze the exit ticket data, we calculated the mean and standard deviation of all responses for each module. Survey responses were analyzed across all modules collectively. This choice reflects the study's focus on students' overall perceptions of sociotechnical content within engineering courses, rather than evaluations of individual modules or topics. The modules functioned as a common instructional format through which sociotechnical content was introduced. This allowed us to examine how such content, when integrated into technical coursework through the use of modules, influences student support of sociotechnical consideration and their desire for increased inclusion of this material.

We analyzed the interviews using thematic analysis with an inductive coding approach. We developed an initial set of codes and applied them to the entire dataset in MAXQDA24, updating the codebook as necessary. Quotes presented in the paper are edited for clarity.

Results

Results indicate strong student support for sociotechnical content in technical engineering courses. Both the exit ticket responses and interviews suggest most students found the modules to be valuable and expressed interest in the integration of social content in their technical engineering courses.

Exit Tickets

The number of responses, mean, and standard deviation for exit ticket data is included in Table 3. For the Energy Burden module, students expressed a strong desire for more sociotechnical content within the course more broadly (M = 5.57, SD = 1.14, n = 53), indicating interest in additional opportunities to engage with these topics. These results suggest that the module was well received. For the Prioritizing Power module, students again expressed strong interest in seeing more sociotechnical content integrated into the course (M = 5.79, SD = 1.16, n = 47). This result also indicates that students would like to engage with similar material in the future. Finally, for the Energy Efficiency module, students also expressed a strong desire to have more opportunities to learn more about sociotechnical content (M = 5.40, SD = 2.51, n = 5). While the overall data is positive, the limited sample size makes it difficult to generalize these findings.

Table 3: Exit Ticket Data for Prioritizing Power Module

	Total Responses	**Mean**	**Standard Deviation**
Energy Burden			
University A	53	5.57	1.14
Prioritizing Power			
University A	40	5.80	0.93
University B	7	5.71	2.13*
University A and B	47	5.79	1.16
Energy Efficiency			
University B	5	5.40	2.51*

*The large standard deviation observed for University B likely reflects the small sample size. Because our analysis is intentionally conducted at the module level rather than the university level, this variability does not undermine the study's primary findings. The split by university here is presented for clarity only.

Interviews

All interview participants expressed support for discussing social issues within technical engineering courses, and they consistently described the modules as valuable and relevant. Students described three main reasons they want more sociotechnical content in technical courses: (1) it broadens their understanding of engineering practice, (2) it contextualizes technical material, and (3) it highlights often overlooked responsibilities of engineers.

Students want to see more social issues in technical engineering courses.

Students want to see more social issues in technical engineering courses, primarily because they felt it could highlight things that are often overlooked in engineering. They emphasized that sociotechnical content helped broaden their perspective of engineering practice. For example, Ivan talks about how his perspective was broadened by the modules because they highlighted the importance of designing for maintenance and long-term responsibility, rather than designing for obsolescence. He said,

> *"A lot of the engineering courses focus only on specifically trying to make without trying to maintain. Maintenance also should be a thing that is focused on in engineering courses. I feel like the social aspect you're thinking about with the hospital and the light bulbs highlight the idea of maintenance …and how we need to ensure those structures continue to be maintained. Well, I feel like this is an important part [of] being an engineer."*

Will also supported the point that the modules helped to broaden perspectives by encouraging students to understand the broader societal context of engineering work. He said,

> *"I think [social issues] need to be added. ... a lot of engineers focus on the technical side. But the social side is important too. I think it's good to see how what you're working on is affecting the world, and areas of improvement, not just on the manufacturing side, but on the business side and the environmental and political side."*

Participants talked about wanting to learn more social content because they believed in its importance, further solidifying student interest in the modules. It is notable that participants raised these suggestions when they were asked what they disliked about the modules. For example, speaking about the Energy Efficiency module, Will said,

> *"I would say it probably would have been nice to have some more problems to work on… or more applications…We need more awareness. And we need to promote awareness amongst our peers and general society because that is a big issue with renewable resources and this new technology [LEDs]. If it isn't being promoted and it doesn't get around, there's no way people can support it, and if it doesn't get traction in our society, the plan usually gets scratched."*

Other students appreciated how the social content complemented the technical content, giving further support for including more sociotechnical content in technical engineering courses. For example, Quinn talked about how the modules helped contextualize technical material,

> *"In general, it was fun to have a little nice break from all the super technical details of circuits. It helped me really relate these concepts to what we're doing in the real world,*

because most of the other lectures are 90% technical and you don't even know how you would use it in real life. The modules weren't too broad…I think it was very useful."

Molly also agreed with this point by appreciating how the modules encouraged thinking beyond prescribed steps and enhanced the appeal of the engineering major as a whole. She said,

> *"I think [introducing social issues in engineering] is really necessary. [For] a lot of engineers or future engineers like myself, it's just so easy to get wrapped up in solving a circuit problem and just following the steps. Being able to see how your work will be applied in the future, or your future obligations as an engineer… especially if someone's iffy on joining electrical or computer engineering, then I feel it would cement their choice."*

Additionally, Brendan's reasoning for the importance of introducing sociotechnical content into more technical courses was that even though engineers may not generally start out with bad intentions, it could be worthwhile to teach them to think beyond their own immediate goals. He said,

> *"I think [introducing sociotechnical content] is a good thing. I think that if you kind of raise engineers that have no consideration, I mean ideally, they would naturally want to do good things. But perhaps they wouldn't go about it in a way that's actually considering all aspects, or maybe they'd be just unsuccessful because they aren't considering everything. Or perhaps they start like doing maybe more shady things."*

While some participants thought it was important, others cautioned that too much sociotechnical integration could make it repetitive and redundant. Explaining this point, Noah said,

> *"I don't think [sociotechnical issues] need to be in all technical classes, because it might be kind of redundant. I think it would be good if it was introduced in all the intro classes of the various engineering fields, so new engineers could be introduced to how their potential majors could be used to solve social issues."*

Talia similarly emphasized the value of integration in courses she found meaningful saying,

> *"And I really don't wanna take a random ethics class anymore. So it's nice that it's integrated into classes I actually care about."*

Overall, the interview data indicate strong student support for incorporating sociotechnical and social issues into technical engineering courses, with participants consistently emphasizing how such content broadens their understanding of engineering practice and highlights considerations that are often overlooked. Students valued the way sociotechnical perspectives contextualized technical material, encouraged more reflective and responsible thinking, and enhanced their engagement with the engineering curriculum. While a few participants expressed concern that excessive integration could become repetitive, none suggested eliminating sociotechnical content altogether. Instead, their comments point to a desire for thoughtful, balanced integration that meaningfully connects social considerations with technical learning. This supports the perceived relevance and importance of these modules within engineering education.

The modules reinforced student perspectives on social issues in engineering.

The majority of students said that the modules reinforced their perspective on the importance of introducing social issues in engineering courses. Supporting this point, Talia said the following about how the modules influenced her perspective on social responsibilities:

> *"I think [the modules] mainly strengthened [my perspectives on social issues in engineering] because like I mentioned, I took a sustainability course last semester, and that was about being good engineers, and so then, tying that perspective to electrical engineering [through the module] was really nice."*

Other students talked about how the modules helped to more clearly articulate their perspective. For example, Nia said,

> *"[Before this session], for the most part, I had a very broad perspective. I think now it's a little bit more clear and…They're all specific things that I can go back to and say, 'This is how as an engineer, I can make an impact,' versus just saying, 'Oh yeah, I'm an engineer and I want to help people.' Now I can bring up specific examples and think of specific things."*

Niko further emphasized the value of learning about societal challenges, emphasizing that this reinforced his perspective on the importance of integrating social issues in engineering courses beyond ethics courses. He said,

> *"In addition to a basic engineering ethics course, where we hear about the 'whoopsies' of major corporations in the past that have intentionally or unintentionally damaged society, it would be very useful to understand, similar to energy burden, the lesser known problems that society is facing so that engineering students don't accidentally perpetuate those problems, and also so that students can start to envision themselves fixing those social justice problems on top of the classic engineering challenges, making things better, faster, stronger."*

Students also talked about how they had positive experiences with modules, which made them want more similar opportunities in the future. Responses also illustrate that students thought this module was more effective than other material they had previously encountered. Supporting this point, Amar said,

> *"After my strong experience with those lectures, I would love to have similar lectures like that in the future. It would help me understand the real world, not just circuits, a lot better. In my engineering foundations class, we also had similar modules as well, but I felt the way [this course] did it was a lot more collaborative and engaging."*

In summary, students generally reported that the modules either reinforced their existing views or clarified their understanding of the importance of addressing social issues in engineering education. For many, the modules helped articulate perspectives they already held, strengthening their belief that social responsibility should be integrated throughout engineering courses rather than confined to standalone ethics classes.

Discussion

Across exit ticket data and interviews, students expressed strong and consistent support for integrating sociotechnical content into technical engineering courses. High exit ticket ratings across all surveyed modules indicate a clear desire for more opportunities to engage with social issues. Interview responses highlight how the modules broadened students' understanding of engineering practice, reinforced or clarified their sense of social responsibility, and helped contextualize technical material through real-world examples. Students valued the relevance and engagement of the modules, often describing them as more effective than prior ethics or sociotechnical integration, while also noting the importance of thoughtful, non-redundant integration. Importantly, these findings help address instructor concerns about potential student resistance [12], as students not only accepted but actively valued and requested more sociotechnical integration.

There are some limitations to our findings. For instance, students who volunteered for the interviews may have more positive attitudes than those who did not. The possibility of self-selection bias cannot be ruled out. In addition, the small sample size of University B doesn't allow a comprehensive statistical analysis.

It is also important to note that students at both schools mentioned that there were other points in the engineering curriculum where they encountered sociotechnical content. Students at University A, like Niko, described that in project-based foundational engineering courses, professors would talk about the impact of their technical coursework. Students at University B, like Nia and Talia, also reported that some of the content taught in the Energy Efficiency module was introduced to them elsewhere in the curriculum. Both universities also teach ethics and sociotechnical content at other points in the curriculum.

The familiarity with sociotechnical integration among students at both schools may have contributed to how positively students felt about the modules. Previous findings from this project offered a range of opinions when similar modules were implemented, with a more significant subset of study participants feeling negatively or neutral about the modules [13]. At the university where that data was collected, sociotechnical integration is less common across the undergraduate engineering curriculum and was not mentioned by any students in those interviews. Existing research also shows that instructor positionality and institutional context also impact how sociotechnical content is integrated into engineering and student response. [16]. In this paper, however, we refrain from making definitive interpretations of differences in student support across institutions, given that the data are analyzed at the aggregate level across modules. Future work could explore more directly how institution type influences student perceptions of sociotechnical content integrated into technical engineering courses.

Conclusion

Analysis of student responses to sociotechnical modules embedded in introductory circuits courses shows that these engineering students support sociotechnical content integrated into engineering courses. Quantitative exit-ticket data consistently indicated high levels of student interest in additional sociotechnical content, while interviews explained why students valued these experiences. Across the interviews, students described sociotechnical discussions as engaging and relevant for understanding the broader implications of engineering work. Using modules as the method for sociotechnical integration was appreciated by students because it strengthened their perspectives and gave them a better understanding of what it meant to be a responsible engineer. These results are encouraging for engineering instructors interested in integrating sociotechnical content because these approaches are well received by students and can play an important role in better preparing graduates for the sociotechnical realities of the engineering workforce.

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