Shaping the macro-ethical reasoning of engineers through deliberate cultural practices

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Abstract

Most engineering ethics education is segregated into particular courses that, from a student's perspective, can feel disconnected from the technical education at the center of their programs. In part to counter this disconnect, several immersive programs designed to train engineering students in socio-technical systems thinking have emerged in the U.S. over the past two decades. These programs provide alternative ideologies and practices intended to counter dominant cultural paradigms that marginalize macroethical thinking and social justice perspectives in engineering schools. In theory, longer-term immersion in such programs can help students develop alternatives to these harmful ideologies. However, because cultural change is difficult to study, few studies provide a thick description of these alternative cultural practices and their impacts. Our study offers a rare glimpse of student uptake of these practices in a multi-year Science, Technology, and Society (STS) living-learning program.

Specifically, our study explores whether and how cultural practices within an STS program help students develop and sustain a socio-technical systems thinking approach to engineering practice. We ground our work in a cultural practices framework from Nasir and Kirshner [1] which, roughly speaking, understands practice to be "a patterned set of actions performed by members of a group based on common purposes and expectations, with shared cultural values, tools, and meanings" ([2, p. 99] as cited in [3]).

Looking across the enactment of practices in classrooms and students' interpretations of these events in interviews allows us to describe the multiplicity of meanings that students distill from these activities. This paper will present multiple cultural practices we identified as particularly salient to students in the STS community at the University of Maryland in College Park:

- cultivating an ethics of care,
- making the invisible visible,
- understanding systems from multiple perspectives, and
- empowering students to develop moral stances as citizens and scientists/engineers in society.

In the STS program pedagogy and in students' uptake, these practices are entangled and interacting. Both to bound the scope of our analysis and to illustrate these entanglements, we center *cultivating an ethics of care* in this study and relationally explore the other three themes through it. A major finding is that an ethics of care manifests in two ways in the data. Students talk about how an ethics of care is part of the STS program community and how the STS program fosters an ethics of care toward communities outside the program through human-centered engineering design. The centrality of the *same* overarching cultural practice across both its "internal" and "external" relationships may serve to stabilize an orientation toward prioritizing human rights, capabilities, and wellbeing across communities.

*The first two authors contributed equally to this work.

I. Introduction

In the past couple decades, several engineering schools in the United States have experimented with immersive programs designed for engineering students to explore macro-ethical or socio-technical systems thinking [4]-[6]. Arizona State University launched one in 2016, Virginia Tech recently proposed a program, the Colorado School of Mines has an undergraduate Humanitarian Engineering major, and the University of Virginia requires engineering students to take STS courses throughout their four years and complete a senior STS thesis paper. Over 30 schools have STS programs that grant either a minor, major, citation, or certificate. The motivation to create such programs stems in part from the realization that the professional formation of ethical engineers is not just a matter of providing knowledge but also a matter of countering long-standing institutional engineering cultures that support socially harmful mindsets and ideologies (e.g., [7]-[10]).

Historically, engineering schools have satisfied ABET ethics and life-long learning standards through stand-alone courses focused on professional ethics ("micro-ethics") and/or single lectures within technical courses. Students report that their courses mostly treat ethical issues as separate from their technical training, or do not address ethical issues at all [11], [12], [13]. Emerging research helps explain why these stand-alone approaches have limited effects on students' long-term ethical thinking. Engineering schools overwhelmingly send the message that acquisition of technical knowledge takes precedence over understanding how to use that knowledge ethically [9], [14], [15]. Furthermore, research on moral development (mostly from non-engineering contexts) in general supports this view: The development of moral behavior and moral identity is entangled with the participation structures and practices in which individuals engage as members of specific communities whose goals, values, and principles are embodied within those practices [1], [16], [17]. In brief, single courses or add-in modules about ethics are overwhelmed by the broader engineering culture that keeps macro-ethical and social justice perspectives on the periphery [7], [8], [18]; countering technical narrowness, along with other predominant ideologies and mindsets—depoliticization of science and technology, positivism, the influence of the military-industrial complex on engineering education, and so on—requires a more suffusive approach.

We shouldn't expect countercultural immersive programs to be a magic bullet, however. While promising, immersive programs focused on macro-ethical reasoning as a means to challenge dominant institutional culture are usually embedded within the culture they aim to counter. Although students in these programs often take several courses and participate in co-curricular activities for two to four years, these program activities are interspersed between technical courses, major programming, and symbolic experiences that reinforce traditional engineering culture. Furthermore, because most K-12 education reinforces positivist and techno-optimistic narratives about the ability of market-driven and/or "hero"-driven innovations to solve social problems [19], most engineering students come to college consciously or subconsciously invested (at least partly) in the corresponding corporate "socio-technical imaginaries"—visions of how corporations and workers within corporations can improve society by striving for efficiency, marketable solutions, and so on [20], [21].

For all these reasons, we expect that students' development of macro-ethical, socio-technical thinking and their uptake of cultural practices embedding these ways of thinking will be context-dependent and episodic, not linear or uniform across different students. This makes it difficult to study our research question about whether and how cultural practices within an STS program help students develop and sustain the social and intellectual resources for using a socio-technical systems thinking approach to engineering practice. The influence of cultural practice on student thinking is inherently difficult to describe, partly because engineering itself is a complex "mangle of practice" [22] and partly because students bring many standpoints to the practice of engineering, expressed in a variety of ways. Immersive countercultural engineering programs have the potential to introduce new cultural practices into the existing mindsets and practices of students. What students find salient about these encounters is hard to track and how they relate to these cultural practices evolves (non-linearly!) over time in interaction with other institutional influences usually embodying dominant engineering culture. Furthermore, because these mindsets and practices are interwoven and students interpret them in a variety of ways dependent on their personal experiences and identities, it is difficult to systematically characterize the influence of new cultural practices on students. So, any one study of an immersive engineering program centering macroethics is going to be a snapshot into a messy process that is difficult to capture [23]. Nonetheless, the growth of immersive countercultural engineering programs in U.S. engineering schools makes it important to pursue such studies. By doing so, we can begin to chart the landscape of how the introduction of mindsets and cultural practices designed to counter harmful incumbent ideologies of engineering culture are playing out for engineering students.

In this paper, we report findings from an examination of the cultural practices for ethical engineering within the Science, Technology, and Society Living and Learning Community (STS-LLC) at the University of Maryland (UMD) in College Park, MD. The STS-LLC program is aimed at engineering undergraduates in their formative freshman and sophomore years, when the program can shape their visions of ethical engineering. This program explicitly strives for cultural change in engineering practice and mindsets through the scaffolding of an STS Postures pedagogy [24], a whole-person approach which aims for students to embody alternative ideologies and practices that stabilize one another. Through service learning, public engagement, practicums, colloquia and peer-bonding activities, students come to participate in cultural practices that emphasize socio-technical systems thinking, human-centered design, and a culture of care.

We are interested in how students take up these ways of being and doing scaffolded by the STS-LLC program. We provide observations and descriptions of many of the mutually reinforcing skills (practices) and "mindsets," existing at different grain sizes, that students have found salient. These salient practices and mindsets manifest in two basic ways: (i) the community building practices and norms of the STS program and (ii) emergent ways that students talk about STS curriculum and activities (including its service learning experiences). Four salient themes emerge from this study of students' experiences in the first year of the two-year STS program:

1. examining things from multiple perspectives to make sense of issues/systems,
2. making the invisible visible,

3. empowering students to develop moral stances as citizens and scientists/engineers in society, and
4. prioritizing human wellbeing (an ethics of care).

Not surprisingly, these four themes are highly interrelated and emerge in different ways and with different degrees of salience for different students, which makes analyzing these themes as independent features of the program impossible.

Because of the complexity of the interplay between the scaffolding of the STS Postures pedagogy and the emergence of these four themes, we have chosen to center *prioritizing human well-being (an ethics of care)* in this analysis and relationally explore the other three themes through it. As with the data in general, this theme manifests in two basic ways in the data. First, students talk about how an ethics of care is part of the STS program community through programmatic infrastructure, the way peer-to-peer interactions are structured and scaffolded by program instructors. Second, the STS program fosters an ethics of care toward the communities students will design with and for. The four themes often intersect for students when talking about designing for communities within the STS program. In general, our paper explores how the UMD STS program fosters an ethics of care through cultural practices and mindsets that embody socio-technical systems thinking. A hypothesis emerging from this work is that the ethics of care gains stability and salience in students' ways of thinking and being due in part to its centrality in both the internal norms of STS community and in the program's human-centered design orientation toward interacting with other communities. If confirmed, this hypothesis suggests that countercultural engineering programs more generally should focus on practices and mindsets that cut across the internal norms of the community and its orientation toward external communities and stakeholders.

Our study setting: The STS program

Our research study partners with the directors, educators and students of the College Park Scholars STS Program. The program is typically a living-learning community (LLC) where approximately 85 students live within the same dormitory across the first two years of the program. This study took place during the COVID-19 pandemic, when 57% of STS students attended school entirely remotely. This proportion increased over the academic year as students decided it wasn't worth staying in the dorms when people were discouraged from interacting or eating together. Thus, the COVID-19 pandemic disrupted students' social and academic lives, drastically minimizing opportunities for interacting with peers and instructors, changing the way they participated in courses, and creating many barriers for accessing paid work.

The STS program is the only UMD Scholars program sponsored by the College of Engineering. As such, it draws in many students majoring (or hoping to major) in engineering. At UMD, engineering is a Limited Enrollment Program with "specific gateway requirements for admission" that "determine their enrollments on a space-available basis." At the start of the year, the program had the following composition of majors: 54% majoring in engineering, 23% majoring in computer science, with the rest of the cohort coming from letters and sciences, information sciences, architecture, psychology, and finance.

The STS-LLC is structured through a 15-credit curriculum that begins with a first-year *Introduction to STS* course broken across two semesters (Fa: 2 credit, Sp: 1 credit). Students also take a practicum course where they work with local community members on a science and technology issue (e.g., Infrastructure and Society, Robotics Service Learning in K-12 schools, Ecuador Study Abroad). The 2-year program culminates with the STS Capstone where students develop their own STS questions focused on the governance of science and technology and create a deliberation about their topic in which first-year students and invited guests participate. The STS Program oriented to the COVID-19 pandemic as a deliberate object of inquiry – at times using ethnographic methods to understand college community members' lived experiences during these tumultuous times, examining sociotechnical systems shaping vaccine development and distribution, and critically analyzing the disproportionate health and morbidity impacts of the COVID-19 pandemic on Black and Latinx communities.

Focal data for this paper include interviews of first-year students in the midst of taking the introductory colloquia (CPSS 100/101) in Fall 2020 and Spring 2021 as well as ethnographic observations of these course settings. This timeframe coincided with the height of the COVID-19 pandemic when most classes were on Zoom or asynchronous. The STS instructors of the intro course (Tomblin and Mogul) worked to emulate the interactive and experiential nature of the in-person version of the course in an online setting. The in-person version of CPSS 100 meets once a week for approximately 90 minutes and is designed to build community among students, acclimate students to campus life, build relationships between students and program faculty, foster career development, and introduce the STS Postures (described below). The first thirty minutes of class time are typically spent as a whole group with the faculty instructors covering the main themes of the day through a mix of lecture and group activities. In the last hour, former-STS-student TAs lead activities that reinforce the STS Postures and topics covered in the first 30 minutes. To adapt to online instruction, the instructors recorded a "lecture" for students to watch and respond to prior to meeting with the instructors. The synchronous sessions with instructors reinforced the recording with an interactive activity and discussion. In the TA-led discussion sections, students did "stokes" (community-building activities) and worked on semester projects like the Stakeholder Interview and the Community Futures project (see Sections II.C & II.D).

II. Deliberate design of STS pedagogy within the STS program

In this section, we discuss the pedagogical and community-building strategies of the STS program in much more detail than is typical in a paper of this sort. We do so for two reasons. First, we'd like this paper to be in conversation with creators, leaders, and instructors of other STS programs and of other countercultural engineering programs more generally, to facilitate exchange of ideas. Second, from a research perspective, our findings are about *this* program, and hence readers need a detailed understanding of the program to join us in thinking about how to interpret the underlying mechanisms of students' uptake of cultural practices and mindsets in order to generalize aspects of the findings beyond UMD's particular STS program.

A. Why "Postures"?

In past years, the STS instructors initially struggled to connect with STEM students, especially engineering and computer science majors, via traditional STS pedagogies (e.g., [25], [26]). STS instructors encountered "deterministic" mindsets identified in the engineering education literature, such as depoliticization of technology, influence of the military-academic-industrial complex, uncritical endorsement of meritocracy, and disengagement from socio-technical and social justice issues [8], [10], [27], [28]. Traditional STS pedagogies, designed for graduate students, were failing to inspire life-long active and critical engagement with the status quo of engineering, and even seemed to tether students to deterministic narratives about technological development and progress. John Schumacher's *Human Posture* [29] became an inspiration for STS instructors. This work emphasizes the importance of taking intentional postures (e.g. postures of love, curiosity and collaboration) and changing our postures of passive acceptance of the technological status quo. Cultivating student agency unites mind (the traditional focus of STEM education) and body, allowing students to experience the value of gaining empathy for others from multiple perspectives [24]. The STS Postures pedagogy is also inspired by work centered on "Making and Doing" [30] and STS Critical Pedagogies [31]-[33]. Fundamentally, STS Postures involve "holding a reflexive posture that orients the body toward humility, openness, criticality, and action" [34, p. 118].

B. Foundational STS theory

STS Postures pedagogy translates STS theory and jargon into an action-oriented scaffold. Central to this enactment is encouraging student agency in the classroom (e.g., valuing their knowledges, shaping conversations, feeling heard, voicing concerns) and within the broader community (e.g., taking action in other classes, internships, local communities). In order to nudge students away from technical narrowness, students are asked to see themselves as part of socio-technical systems that they have agency to change [35]. Below is some of the STS theory foundational to STS Postures.

1) The social construction of technoscience opens up the possibility for alternate futures. The path of science and technology isn't inevitable and we have agency to imagine alternate pathways and enact those changes. On a fundamental level, the social construction of technoscience theoretically provides openings for the democratization of knowledge production and decision-making and highlights the value of historically marginalized local knowledges. It attends to the way power is reflected in socio-technical systems and whether power sharing exists and/or power is being exerted and treated as a limited resource [36].

2) Politics of artifacts [37] asserts that science and technology aren't neutral. Many of the values and politics of artifacts remain invisible, by design. In order to build socially just socio-technical systems, we must reveal these values in existing artifacts and attend to what values are shaping the design of new artifacts. Otherwise knowledge production and technological development will continue to reproduce social inequalities.

3) Feminist standpoint epistemologies (e.g., [38]) help us empathetically orient "Self" to "Other" in order to recognize the importance of the local knowledges of historically marginalized groups.

C. The structure of STS Postures

STS Postures (or socio-technical systems thinking) pedagogy has three facets: analytical approaches, data collection techniques, and body/mind practices [24]. In 2020 when the study took place, the analytical approaches and data collection techniques were being presented as systems thinking skills, and body/mind practices were enacted through stokes, performances, drawings, and other modes that encouraged students to connect their intellectual work with body awareness; however, this facet had not formally been articulated until Fall 2021 (See Fig. 1 below).

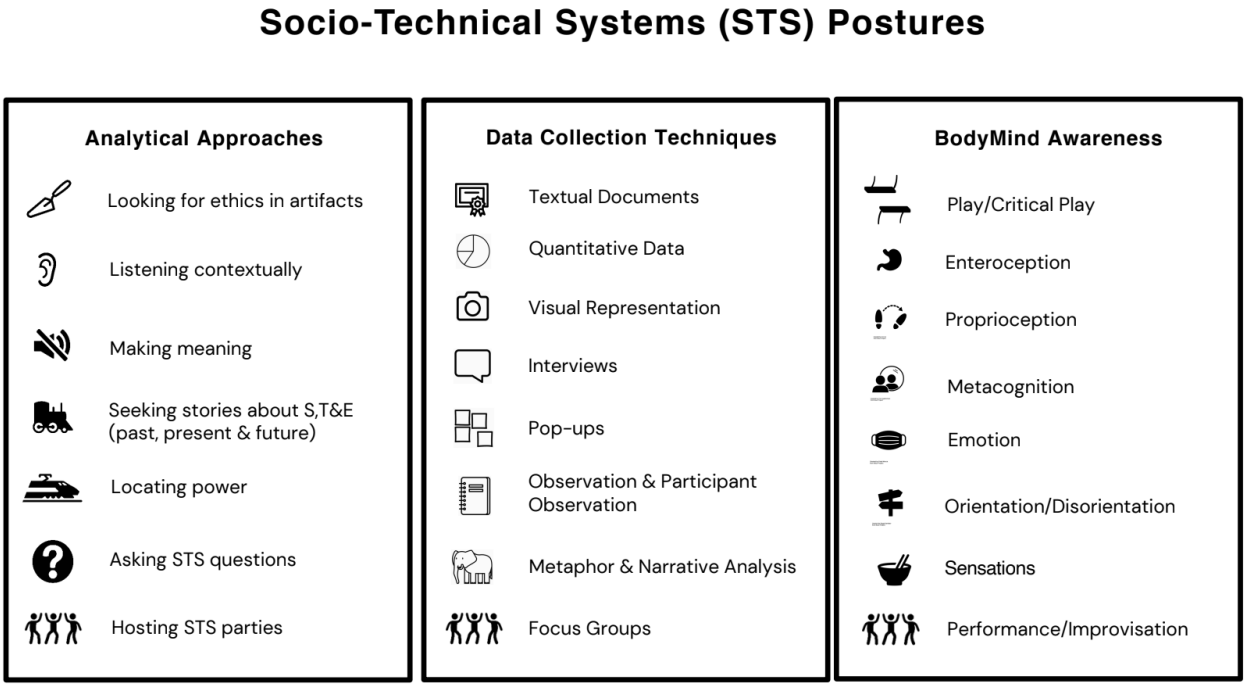

Figure 1. Current iteration of the Socio-Technical Systems (STS) Postures course handout

Analytical approaches - These analytical approaches, originally called STS Thinker Skills [34] (which is the term more typically used by researchers and students in this study), enact the social construction of technology and reflect a shift in mindset from determinist/status quo thinking (Ethics in Artifacts; Making Meaning). These analytical tools help students simultaneously pay attention to the mundane (taken-for-granted) and the new while appreciating the value of perspective taking and historically marginalized knowledges (Listening Contextually; Seeking Stories). It encourages the exploration of how power permeates the production of science and technology but is often hidden (Locating Power in Systems). Ultimately, the analytical approaches frame criticality around science and technology as a 1) a skill at asking critical (STS) questions, 2) a skill to be practiced through discussions and public gatherings (Hosting STS Parties) and 3) a skill that when practiced, enacts agency (Locating Power in Systems).

Body/mind practices - A primary assertion of STS Postures is that students won't overcome the socio-technical divide, technical narrowness, and a lack of concern for others unless we break down the long-standing habit in STEM disciplines to separate the mind from the body, and

devalue relations with the body. Failure to activate the role of our own politics, emotions, and embodiment of experiences in how we think leaves us with limited capacity to connect to others. This is tragic because developing intimate connections with other people aids us in more complete understandings of the socio-technical systems in which we find ourselves embedded, in what Sandra Harding calls Strong Objectivity [38]. The body/mind reconnection occurs through activities such as stokes, performances, data collection that attends to non-visual senses, and playing with artifacts, among others.

*Data collection technique*s - This facet is a linchpin between the analytical approaches and the body/mind practices. Asking students to collect data activates student agency to explore and question the status quo. Data collection puts students in motion, enacts emotions and bodily feelings, and taps into student experiences with others (body/mind). It is a means for caring about what other people think about science and technology and including their views of design and policy (Analytical Approaches). When planning interactive classroom activities, the data collection techniques function as a menu for choosing the way to operationalize the analytical approaches in the classroom or for prepwork.

D. Introducing salient STS assignments and course activities

Our analysis revealed several assignments and activities that were salient to first-year STS student uptake of STS Postures and cultural practices. We describe four of them here briefly, as they come up frequently in the way students talk about the first-year of the STS program.

The Stakeholder Interview Project - In the year-long stakeholder interview project, students worked in small groups to interview a campus stakeholder about the impacts of the COVID-19 Pandemic on their professional and personal lives. They then chose artifacts that were central to the stakeholder's experiences to analyze further to begin defining a problem that they would use in CPSS 101 (2nd semester of introductory colloquium) in a design project. In order to make sure groups were defining problems by incorporating multiple perspectives, they were given several analytical tasks to develop a deeper meaning of the artifact and potential issues related to it. This included socio-technical systems mapping of related artifacts, stakeholders, and activities; asking STS questions from the position of multiple systems drivers such as bodily identity, symbolism, professionalism, economics, history, and so on [39]; and an analysis of how metaphors shape the use of their artifact [40]. Finally, students were asked to view all their data collection and analyses through STS thinker skills (e.g., Locating Power in Systems, Ethics in Artifacts) in order to frame STS questions that suggest important problems needing to be addressed. These questions were reintroduced in the spring semester to inspire design projects to address needs of their stakeholders.

The Community Futures Project - In a months-long project, students explored multiple community spaces–two in-person and two online. This activity was designed to help students explore the role power plays in shaping and fracturing communities to answer questions like, how are rules inscribed in technology, and who does it serve? Students explored commonly visited spaces (e.g., a community park, an intersection, the Black Lives Matter website) to unearth ethics in artifacts and hidden power relationships between people that design the spaces and people that use/are impacted by the spaces. Using Elinor Ostrom's Core Community Design

Principles [41] to explore the role of power in designing community spaces, students explored how virtual spaces can be designed to empower people but can also limit people's ability to participate. Another prominent activity often mentioned by students is the use of Andreas Gursky's *99 Cent* photograph [42] to introduce the Community Futures project. The students were asked during a session with the CPSS100 instructors to keep Elinor Ostrom's design principles in mind while reconsidering the grocery store experience in light of Gurksy's image.

The Infrastructure and Disability Audit - The infrastructure and disability module centered the role of activism and empathy in infrastructural change. During the online version of the course, students were asked to take pictures in their own communities that related to accessibility. In-person, students were asked to leave the classroom and retrace their steps back to where they had been previous to class, and then return to class, taking notes and pictures along the way, all the while taking the route they would take if they were walking with a friend who was using a knee scooter. This activity had the twin goals of problematizing both accessibility and disability simulations of this type. In class, the instructors showed the pictures students took and had them introduce their findings. They were asked to propose ways they would design a learning experience for other students around these themes. By inviting them to participate in this imagining, students were invited to take on a different stance toward a familiar world. Students' noticings and photo documentation artifacts were then focal to the classroom community's sensemaking about infrastructure and disability.

Stokes - "Stokes," as the STS instructors encountered them in the design thinking curriculum at the Stanford d.School, figure prominently in the first 15-20 minutes of most classes. Stokes are mini-exercises, sometimes lifted out of theater workshops (e.g. "yes, and…", which encourages students to build off each other and improvise based on what someone else has said), at times inviting vulnerability, and sometimes adapted to suit a particular theme. Though challenging to implement, especially when led by teaching assistants, they energize students, let them make literal body/mind connections to senses and emotions and are open-ended to inspire expansive and abstract thinking. For example, a stoke called "Visiting from 2070" asks students to pretend they are someone from 2070 visiting their room. Students are instructed to turn off their cameras and walk around their rooms observing objects in their room from the perspective of a person from 2070. When they return to Zoom, they then report on what they saw. This activity is designed to encourage movement and empathy for others while collecting data about a mundane space. By lowering the barriers to people interacting, sharing, and being present with other humans, these routines serve as foundational skills to enacting an ethics of care in techno-scientific artifacts and practices.

III. Theoretical framework

By *cultural practices* we mean "recurrent socially organized activities" [1]. Consistent with Nasir and Kirshner, we conceptualize cultural practices to be shaped by institutional history/values *and* by interactional dynamics between participants, such as available roles and participants' agency in shaping those roles and patterns of interaction. How students engage in cultural practices *is* an aspect of their practice-based identity [43] which we are interested in modeling in our broader investigation.

Nasir and Kirshner's framework was developed to study the cultural construction of moral and civic identities. Nasir and Kirshner's framework posits three nested spheres that mutually constitute one another: **institutional context** (e.g. history, guiding philosophy and membership), **cultural practices** as recurrent socially organized activities that permeate everyday life (e.g. activity structures and material and symbolic tools), and **social interaction** (e.g. social positioning, authoring, and framing). These nested spheres draw attention to different cultural construction processes which span various temporal and spatial scales. Their theorizing seeks to specifically bring greater attention to microprocesses: "our concern is to understand the microgenetic (moment-to-moment) development of moral identity. In other words, how moral identities are encouraged, maintained, taken up, and rejected in social interactions within activities" ([1], p. 143).

Viewing the STS program through Nasir and Kirshner's cultural practice framework invites us to situate the STS program as embedded in an engineering school at a large R1 research institution (Institutional Context) and as deliberately structured to introduce cultural practices to first-year engineering students that tend to counter the dominant norms of the engineering school. These cultural practices encourage a variety of social interactions that ask students to reflect on: (a) their social positioning, (b) how they are "authoring" themselves, and (c) how they are navigating the framings offered by the college of engineering and framings offered by the STS program. Nasir and Kirshner's framework helped to draw our attention to various cultural construction processes in our data set, as discussed below.

IV. Methods

A. Our extensive data set

Ethnographic observations in the colloquium and practicum courses. In Fall 2020 and Spring 2021, PI Turpen attended most class meetings and one TA-led discussion section of the STS colloquium seminar for all the first-year students in the program. Turpen took field notes, attending to what messages and STS ideas were emphasized, what opportunities students had to embody/enact some of these ideas, and other interactional patterns amongst the students. Turpen was not the only ethnographer present and taking field notes, however. We also partnered with STS program participants we hired as Undergraduate Research Fellows (URFs), who collected field notes in practicum courses during the Spring and Fall of 2021. URFs worked in "data teams" composed of at least one URF currently enrolled in the course, writing reflections at the end of each class, and at least one URF *not* currently enrolled and therefore free to take field notes during class. The URFs who took field notes revised them based on feedback from their peers and from Turpen and Radoff.

Ethnographic observations in instructional preparation meetings with instructors and undergraduate TAs. The undergraduate teaching assistants in the STS program are alumni of the program, typically in their junior or senior years, since STS-LLC is a 2-year program. Observations of the lesson preparation meetings enable us to see how these veteran students engage with the practices emphasized in the program, now within a slightly different context and role. Since lesson preparation often involves going through some of the activities their students will experience, we could observe how veteran STS students engage with these activities,

providing us with some points of comparison to sharpen our own "vision" around students' engagement with STS practices. The caveat, of course, is that what we see is shaped not only by the TAs' longer exposure to STS ideas and more central participation in discourses of technology, but also by their role as instructional leads in their discussion sections.

Interviews with STS program first-years. We conducted 36 one-on-one reflective interviews with STS students midway through their first year of the program (between Jan. and March 2021). These interviews solicited students' sense of community, their macro-ethical perspectives, and the meanings they were making of cultural practices in the STS Program.

Focus groups of 2-4 first-year students reasoning through a complex design scenario. We conducted 12 group interviews—what we call "focus groups"—with 29 STS first-years. Each group was composed of 2-4 students who worked together on course projects (March-May 2021). In each session, we asked the group to design solutions for a grocery store in a "low-income neighborhood" struggling to retain customers due to the long lines that formed during the COVID-19 pandemic—a modification of a prompt by D. Radcliffe, R. Adams, and M. Cardella at Purdue Univ.). While we do not include analyses of focus group data in this paper, please see [20] and [21] for rich examples.

B. Impacts of the COVID-19 pandemic on data collection and analysis

The COVID-19 pandemic changed the way students in the STS program lived and worked, which forced the research team to make creative adaptations to our methods of data collection and analysis. While the research team experienced its own challenges and reduction in work capacity, the move to fully online learning enabled members of the research team to collect field notes in class and planning sessions virtually without the additional physical constraints of travel and transition-time. The online format also enabled the research team to partner with a team of 16 current STS students, who were offered paid employment as Undergraduate Research Fellows (URFs), which increased our team's capacity for data collection and analysis. It was important to the research team to offer paid work opportunities for undergraduate students because many students were struggling to find paid remote work at that time. URFs were particularly appreciative of opportunities to dialogue and sensemake with each other during these times of isolation [44].

C. Justification for selection of case study students

We had limited personnel capacity for developing case studies of all students' experiences in the program. We therefore chose to narrow our data set, by focusing our analysis on a subset of initial student interviews that captured a breadth of incoming student orientations toward the STS program. To do this, we analyzed interviews for evidence of students' (a) initial values alignment with the STS program, (b) initial skepticism about pedagogical approach of the STS program, (c) propensity for growth as evidenced by metacognition and reflective reasoning, and (d) initial awareness of systemic oppression. Quotations were gathered that offered supporting or contradictory evidence of these initial orientations. Since we made these characterizations primarily to inform our selection of case study students, nuance wasn't essential, and we coarsely categorized students as High, Medium, or Low on each of these four dimensions.

In selecting a sample of focal case studies, we drew on students who originally intended to major in engineering. From that pool, we deliberately oversampled minoritized students (compared to their composition in the program), effectively removing some White male students. We also wanted to limit the proportion of case study students that had worked with us as Undergraduate Research Fellows; this cut a few additional students from the engineering pool. We therefore selected a few CS majors as well, prioritizing people pursuing double majors. We deliberately included some students who expressed some initially skeptical orientations towards the STS pedagogical approach and some students who had already been pushed out of engineering/CS spaces after a single semester.

This paper focuses on the resulting subsample of eight focal students (see Table 1). This subsample deliberately includes a diversity of intended majors (mostly within the College of Engineering), a diversity of initial values alignment with the program, and a range of skepticism toward the STS program's pedagogical approach. This subsample included four men (Dwight, Ezra, Berhanu, and Jordan) and four women (Imani, Carol, Cho, and Vanya). These students' experiences offer a diverse set of entry points into understanding the multiplicity of meanings that students distill from the program.

Pseudonym	Intended Major (Sp21)	Initial Values Alignment (H, M, L)	Skepticism about STS pedagogy (H, M, L)	Propensity for growth (H, M, L)	Awareness of Systemic Oppression (H, M, L)
Imani	EE + Dance	M	M	H	H
Dwight	ME	H	L	M	M
Ezra	CS	L	H	L	L
Carol	Biology → Public Health	H	L	H	H
Berhanu	AE	M/L	L	M/L	L
Cho	CS + Physics	H	M	H	H
Jordan	EE	M	L	M	H
Vanya	ME	H	M/L	M/L	M

Table 1. This table describes our characterizations of students' initial orientations toward the STS program. Note abbreviations in the second column include: ME=Mechanical Engineering, AE=Aerospace Engineering, EE=Electrical Engineering CS=Computer Science.

D. Analytical approach

During our first year of data collection, one of the senior researchers conducting participant observations would bring field note excerpts and key quotations from student interviews to

support our team in building interpretations. These early data sessions focused on how students talk about their college experiences, conceptualize power in society, attend to marginalization and possible harms, and show a willingness to be vulnerable and take risks within the STS program. Our Undergraduate Research Fellows, in conversation with one another, also wrote synthesis memos developing claims based on their ethnographic observations. These memos highlighted the importance of the forms of "safe" collaborative group work emerging in the STS program and how the STS program's analytical lenses and data collection practices served to open students' eyes to new perspectives. We began to recognize substantial overlap between (i) the themes and highlighted events identified in the ethnographic observations, and (ii) the events and interpretations salient to the STS students in their interviews. Focusing on this overlap, we then dove back into systematic analysis of student interviews with a cultural practice lens, as described in Section III above.

In particular, in these analyses, we see cultural practices as "a patterned set of actions performed by members of a group based on common purposes and expectations, with shared cultural values, tools, and meanings" ([2, p. 99] as cited in [3]). In this way, we see cultural practices as grounded in recurrent socially organized activities and also as symbolic meanings that are under negotiation through social interactions. Therefore, our accounts of cultural practices are grounded in (1) accounts of collective enactments from classroom events as captured in researchers' field notes and (2) students' reflections in one-on-one interviews. Looking across (1) and (2) allows us to describe the multiplicity of meanings that students distill from these activities and provides a window into how students are negotiating various ways of being within this cultural community which seeks to offer opportunities to develop particular moral, axiological (values-oriented), and epistemological stances toward the world.

In our analysis of student interviews, we gathered evidence along three dimensions: (a) identity markers and cultural practices from settings other than the STS program, (b) students' descriptions of the STS program and STS classroom routines, and (c) emerging cross-cutting meanings. As noted above, our identification of subcategories was informed by the confluence of what students consistently remarked upon, what stood out to our participant observers, and what was of interest to the research team. Our subcategories for students' descriptions of regularly occurring aspects from the STS program and STS classroom routines included Stokes, Body-mind practices, Analytical Framework (or STS Thinker Skills), Data Collection Techniques, and Key activities/assignments. Emerging cross-cutting meanings sought to capture students' accounts of what is important about what the STS community does together. Our subcategories for emerging cross-cutting meanings include four themes or outcomes that are salient to students at the end of their first year of the program. These for themes include the importance of:

1. examining things from multiple perspectives to make sense of issues/systems,
2. making the invisible visible,
3. taking agency in developing ethical and moral stances as citizens and scientists/engineers, and
4. prioritizing human wellbeing (ethics of care).

These four themes arose in varied ways across our student interviews. We strive to model the cultural practices of the STS program that enable these outcomes. As a result, our analysis focuses on weaving together patterned ways that the STS students interacted with educators and peers within the STS program as well as symbols and framings that STS students encountered in their program experiences. When woven together, these findings capture aspects of the cultural practices of the STS community.

V. Results

As noted above, in this paper we foreground *ethics of care* as one way that the theme of prioritizing human wellbeing arises in students' accounts of their experiences in the STS program. Many scholars in education have conceptualized care in classroom settings, including Nel Noddings [45], who describes care in teaching as attending to students' emotional, interpersonal, and cultural needs. We also draw on conceptualizations of care in engineering education, where scholars have applied frameworks of human rights and capabilities [46] to heuristics for engineering design work (e.g., [10], [47]).

An ethics of care manifests in our data in two primary ways: A) cultivating a culture of care in the classroom; and B) emphasizing care for people and communities that we work with in engineering design. Results Section V.A foregrounds how STS community members orient to one another within the STS program, and Results Section V.B foregrounds how STS students orient to stakeholders outside of the STS program. Our results section is divided into subsections A and B corresponding to these two contexts and then subsection C illustrating the connections between the two contexts.

We begin with how an ethics of care arose internally in students' experiences of the STS community through (1) institutionalized structures for cultivating relationships between community members, (2) relationships with peers, (3) relationships with STS instructors, and (4) the pedagogical routines that shaped the nature and qualities of these relationships. Then, in subsection B, we illustrate how students embodied an ethics of care externally in their human-centered design work through (1) valuing multiple perspectives, (2) making the invisible visible, and (3) taking agency in developing moral and ethical stances. Finally, in subsection C, we briefly illustrate our hypothesis of bridging–the claim that one mechanism by which students developed an ethics of care in the context of human-centered design is by extending the ethics of care modeled within the STS community.

A. Ethics of care in STS community

An ethics of care was deliberately embodied by STS educators in their pedagogical practices and program design. This ethics of care was striking and noteworthy to students. By an ethics of care in the STS community, we refer to establishing a foundation of community that strengthens interpersonal ties between its members and developing routines around centering a body in space. Together these routines lowered the barriers that people encountered in interacting, sharing, and being present with other humans. For all university students, the pandemic led to terrible negative mental health outcomes. By leaning into an ethics of care in the classroom, instructors conveyed that students' mental and physical health affected their academic

performance. Supporting students' learning in the STS program therefore involved encouraging students to reach back to these mental and physical qualities of their being and to acknowledge those as building blocks of the STS pedagogy.

There were multiple ways students saw an ethics of care permeating the STS community. Students perceived care ethics to be tied to institutionalized structures within the broader College Park Scholars program which sought to cultivate relationships between community members. Examples included the existence of a Student Advisory committee, the existence of formal peer mentors, and the shared dormitory space. Some students perceived care ethics to be tied to the relationships that emerged between STS instructors and their students. Some students perceived care ethics to be tied to the peer relationships that emerged between STS students as they participated in the program. And finally, many students pointed to how the pedagogical routines of the STS community shaped the nature and qualities of these relationships; students felt there was substantial room for peer discussion within STS courses and many felt that these peer discussions were a safe and respectful space for talking about complicated issues in society. We will show evidence of each of these in turn.

1. Broader program infrastructure as structuring an ethics of care

STS students noticed that substantial infrastructure existed in the program to deliberately cultivate relationships amongst community members (e.g. program directors, instructors, first-year students, and older students that were alumni of the program).

One element of this program infrastructure included the existence and role of a student advisory committee within the program. For example, Jordan shared, "I'm actually on the Scholars' student advisory board, and one of our initiatives was to really look at how we can engage students who are off campus with students that are on campus, and to really keep people connected through the winter break." Jordan proceeded to describe how this board took the initiative to develop Discord spaces for students within the program to reach one another particularly while classes were not in session. Jordan saw these initiatives as having the desired impact of connecting students and supporting their communication, as Jordan described, "...daily we would send messages to each other. And it's been really nice to keep in touch with other scholar students, and even students from STS." Here we see that "keeping in touch" with peers was valued within this scholarly community. These accounts from Jordan illustrate how the existence of the student advisory committee enabled students certain forms of agency over defining community issues and contributing to developing approaches to addressing those community issues.

One element of this program infrastructure included the existence of a shared dormitory space where students that were living on campus could reside together combined with the fact that students were taking a subset of their classes together. Berhanu described how this element of the program's design contributed to the tight-knit relationships between students. Berhanu shared, "I like how STS makes it so that it's almost like a family because I know that depending on the [Scholars program] you choose, you live in a hall, right? A residency. And that's one thing to already build relationships. And if you have similar classes with people while in the same dorm, on the same floor, that will help to build a tight-knit community. And I like that community

aspect of STS because they're very supportive." Here we see how the opportunities to spend substantial time together across settings served to strengthen relationships.

Another element of this program infrastructure included the existence of a peer mentoring program and the roles and relationships that these peer mentors cultivated with first-year students. The importance of peer mentors in this program may have been accentuated by students navigating the pandemic. Imani described peer mentors as follows, "They also gave us peer mentors at the beginning of the semester and mine, she's a little bit more active, at the beginning of last semester. …she would just like, send us positive messages. Just randomly and like ask us how we're doing. And I was like, I mean, I don't think weird is the right way, like, right word to describe it, but it just caught me off guard and I appreciated it and I would respond back to her and ask her how she was doing. Um, so in that sense, I think that's how they try and cultivate social interactions." Here we see how the ways in which the peer mentors in the program were proactively reaching out to students to check in on them and their wellbeing was surprising, but appreciated. Imani at least interpreted this as a proactive step toward encouraging social interactions between peers. Jordan also elaborated on the important role that peer mentors can play for students, "I applied to be a scholar's peer mentor, and how I think of the idea of being a peer mentor is that it stretches beyond just educational and professional. And so like, it's beyond giving your mentees resume advice. And when you're a peer mentor, you really are also appealing to that emotional side and you've become a part of a student's support system. And so, being a peer mentor would be really important to me, because I'm really big on representation. And right now, there's no Black male peer mentor. ...And furthermore, I think there's no Black peer mentor within STS. And so that's a role that I want to step up into, because different, I guess, like within the university, you'll have different experiences based on your background. I want to be able to be a resource to incoming STS students." Here Jordan elaborates that peer mentors become an important part of students' support system that offers emotional support. Jordan in particular sees the importance of addressing representation issues in the team of peer mentors and sees himself as able to step up to offer support tailored to students' different backgrounds and racialized experiences in the future STS cohorts. Through this peer mentor program, students take agency to support their peers and shape the STS community.

2. Qualities of peer interactions within the STS program

Many STS students in our study also spoke to important qualities of relationships that emerged between students particularly in terms of being able to build ideas together, conveying respect toward differing opinions, and taking collective responsibility over collaborative projects. For example, Jordan described how conversations in Zoom breakout rooms would typically unfold: "I guess the natural flow from person to person was pretty evident. We would all be able to jump on and off of each other." Here we see that Jordan valued how STS peers were able to build off of one another's ideas. Jordan pointed to the importance of discussion norms being reiterated and how that resulted in "being able to have conversation comfortably and respect everyone else's opinion." Students valued the safety to share their own ideas and engage with other perspectives. Holistically, these meaningful relationships with peers in the STS program were important to students. Jordan conveyed this by saying, "being able to meet other STS students was probably the highlight of my semester."

Jordan also shared how collaborative projects, like the *Stakeholder Interview Project* enabled students to build relationships with one another and enabled students to take some agency over course activities:

> "...in our colloquium classes, we'd be shifted into different breakout rooms with partners. And so, for one of our first assignments, we had to interview a stakeholder. And just, something that I really liked is just open communication with two of my partners...Working together was really cool. I feel like I got to know them a bit more. And it really made the project go smoothly. We had a general directive, but we were able to interpret it in our own way and to make our interview pretty cool."

Based on fieldnotes and interview data, many students found being asked to interview a stakeholder from the campus community in the very first weeks of class a bit intimidating and stretched their comfort zone. This also created an opportunity for students to come together around a challenge, adapt to the needs of their peers, and improvise with their interviewee. These activities therefore created opportunities to build bonds with peers and with an extensive network of people within the broader campus community.

3. Qualities of student-instructor interactions and relationships within the STS program

Many STS students in our study also spoke to the critical roles that the STS instructors played in building a community that supports one another. For example, Berhanu described,

> "And I like that community aspect of STS because they're very supportive. The professors are very nice. They always mention that if you do need to talk to them about, even if it's not about STS, you can go to them and they'll listen to you, and that they instill those values into the students that take the classes. So they do help to make a nice, tight-knit community that works together to support each other. And that's one thing that I really do like about the program."

Here Berhanu conveyed that the STS instructors are part of a support structure that you can rely on to be there when you need them and be willing to listen. This student conveyed a sense that STS educators are invested in students' wellbeing and see program success as extending far beyond narrow metrics of grades and academic performance.

4. Students' experiences with STS pedagogical routines and practices

Many students across our interview set spoke to the recurring opportunities for social interactions with peers throughout the program. One student, Carol shared, "we start off with a thing called a stoke, which is kind of like, getting your brain ready for what you're going to be doing for the rest of class, and then it's also kind of like an ice breaker. So I guess that's also another way that they try to build a community inside of the program.." Carol went on to say about stokes, "I think it's to get us relaxed and ready for class." As mentioned earlier, Stokes was one routine for inviting students into grounding themselves in this collaborative space, establishing body/mind connections, and getting a taste for the key ideas of the day. Here we see Carol recognizing the community-building and body-centering purposes of stokes.

It was noteworthy to students that they were regularly expected to talk and discuss their ideas with one another. This was otherwise quite rare in their other science and engineering coursework. Imani powerfully communicated this:

> "STS is really the only class where I'm able to interact with my classmates, which I'm very grateful for. Um, even with just like our group projects, we've gone to, I've gotten to talk with other kids, like on other zooms where we just like, get to know about each other and where we're from and where we went. Um, and even though they're not like super in-depth conversations and really like deep friendships that I'm building right now, um, it just kind of made me realize like how little I'm talking to other people, like other new people. [...] so I really am appreciative of getting to speak with other kids through STS."

Here we see these opportunities to talk to "new" people being particularly salient for students, who at the time were having very limited interactions with anyone outside their own household.

Many students were aware of how the deliberate construction of discussion norms in the STS courses enabled students to be responsible for the impacts that their words and actions had on their peers and encouraged students to orient to differing perspectives and opinions with respect and curiosity. Jordan described that one of the discussion norms that an STS instructor introduced was, "Owning your impact." Jordan described that, "I think about it a lot because it really makes us think of, I guess the broad definition of it is how, what you meant with your words versus how it's perceived by other people. …And so, that 'own your impact' principle really sticks with me whenever I'm in a discussion." Jordan also described that these discussion principles "were reiterated to us a couple of times" and enabled respectful conversations to unfold between peers.

Some students were aware of how the instructors gave students a lot of freedom and agency over sustaining and facilitating discussions with peers, over directing conversations towards things that they cared about and over making activities their own. For example, Jordan described,

> "It's definitely pretty open. …it's really up to us to facilitate the discussions. …But instead of just the TA just keeping everything focused and following some sort of agenda, it's really up to us in the STS discussion to kind of influence what we do. Like, there'd still be the main goal of doing whatever in the assignment. But just the speaking to each other and speaking to the TA, whatever, our feedback really kind of dictated how the conversation would go."

In other moments of the interview, Jordan conveyed that these freedoms also permeated students' interactions with the STS faculty. Jordan shared, "...the conversation would be. It would just be like the UTA [undergraduate teaching assistant] and Dr. Tomblin would just watch and observe, and we would kind of just go at it, and interpret how we thought things were supposed to go." Jordan also commented on the deliberateness of this pedagogical practice, "there's a specific word that they like to use, and it was called you have agency. And so it's like us having the directive to make decisions."

Some students interpreted STS instructors as attentively observing and listening to their conversations with their peers with genuine curiosity in students' reasoning. This was remarkable to students and rare in their past educational experiences. Imani described this in the following way:

> "I think they just want to encourage kids to just like say what they think really. Um, I do truly think that like other people's opinions are valued because…. sometimes in class, someone will say something that the professor doesn't really agree with and they'll be like, ah, yeah, I guess, and then they'll just move on to something else. Um, but if it's something that like maybe Dr. Mogul, like didn't really think about, she'll like ask them to expand on their point. She'll be like, I don't really understand what you're trying to say. Like, could you elaborate? Um, which I think is a really cool way of like talking to students. I had never experienced that before."

Imani experienced the STS instructors as being genuinely interested in their students' opinions and perspectives. Imani contrasts STS instructors' practice of inviting further elaboration on differing opinions as very different from the more convergent thinking encouraged by educators in other settings.

Ethics of care as a foundational practice in the STS program is particularly important because of the program's mission of developing ethical engineers who build infrastructure and technology that resist systems of oppression and injustice. This shift in status quo priorities and values, from designing for Capitalism to designing for people, requires a complete paradigm shift that begins with how people treat one another in academic spaces. In what follows, we show how an ethics of care in the classroom translates to an ethics of care beyond the classroom, in human-centered design work.

B. Ethics of care in human-centered design

In the broadest strokes, human-centered design puts the needs and wants of those being designed with and for at the center. We show how students' engagement in the cultural practices of the STS community promote perspective-taking, surface the often-invisible ethical impacts of designed environments and technologies, and foster students' agency to take strong moral stances against injustice. These cultural practices often overlap, and the reader may notice one student quotation showing evidence of multiple outcomes simultaneously. Each of these cultural practices are structured through key course assignments and activities and through the use of STS Postures. Across each of these themes we highlight how these structures become meaningful to students.

1. Valuing multiple perspectives

One goal of the STS program is for students to experience the value of gaining empathy for others from seeking out and engaging with multiple perspectives when sensemaking about socio-technical systems. Through engaging with others' perspectives, students began to map out ethical implications of taken-for-granted social infrastructure and physical artifacts. Speaking to the value of looking at artifacts from multiple perspectives, Carol said,

> "There's actually a...STS thinker skill called Ethics in Artifacts, and that's where you find different meanings within, um, different things that, um, how it impacts society itself. So I think it's interesting seeing how many people are affected by one thing and how many different perspectives you could possibly have on one…object. And that's just been really interesting because I haven't really been exposed to a class where you have to think about things from a different person's perspective. And I think that's just- that's definitely been

> really impactful, because...the way that people are affected by something that you wouldn't normally...think about a second time, is really interesting."

Part of human-centered design is recognizing the ways that artifacts can benefit or marginalize people, and Carol's exposure to multiple perspectives helped her see how people can be differentially impacted by mundane artifacts that are designed to be overlooked.

One assignment that supported students to critically analyze designed spaces from multiple perspectives was the *Community Futures Project*, described in Sec. II.D, where students used data collection techniques like *photo documentation* and *field noting ethnographic observations* to critically analyze designed spaces outside the classroom. Reflecting on this assignment, Jordan said,

> "We were studying how exactly spaces were designed and systems were designed, and kind of trying to figure out who were like the decision-makers in the system, what are some of the rules and norms within the system, and trying to understand how spaces are defined…we were supposed to look at two physical communities and two online communities…for the physical communities we got to go out into our own neighborhoods and kind of show what we can bring to the table. And so I went to I believe, I think it was [*park name made confidential*]. And we, within our picture that we were bringing to our group, trying to study and analyze how the system was designed and going back to how some people may be marginalized within the system. Like if it wasn't designed to incorporate accommodations for people with disabilities. Or just understanding how park goers have a voice within that specific area."

Here, Jordan described how his group used *photo documentation* to critically analyze design features of a local park from the lens of park goers with diverse needs to understand how power operates within the system to *dis*able some people while *en*abling others. Looking at the system from multiple perspectives also provided insight into who makes decisions about design and upkeep and who can affect change, highlighting that power might be distributed in complex and nuanced ways.

Another activity that supported students to see issues and artifacts from multiple perspectives was the *Stakeholder Interview Project* (described in Sec. II.D), in which students interviewed a university stakeholder about how the COVID-19 pandemic impacted their personal and professional lives and chose artifacts that were central to the stakeholder's experiences to analyze further. Jordan's group interviewed a stakeholder that supported the campus's online learning management system. Through that analysis, his group examined "how virtual learning was working, and how some people are being again marginalized by it and how other people are benefiting from it." Jordan said that the STS Thinker Skills *Asking STS Questions and Locating Power in Systems* were particularly helpful for "trying to understand just how it was affecting our community." Interviewing this stakeholder provided an onramp for examining this seemingly neutral artifact through the perspectives of different users to understand the positive and negative impacts it had on people, a key feature of human-centered design.

Students also talked about the importance of constructing diverse design teams and critiqued the inequitable outcomes that arise when diverse perspectives are left out. For example, when describing a powerful moment from the *Infrastructure and Disability Audit* (described in Sec.

II.D), an assignment that asked students to collect *photo documentation* in their own communities that related to accessibility, Imani said,

> "It was like I'm listening contextually, which is one of [the STS thinker skills I used]. And I think just being able to listen to others and their needs and like different perspectives… contribute to like meaningful change and improvements. And then like an example of this was…we were looking for infrastructural issues, um, within our community and, uh, someone had shared a picture of their local target and how there was a handicap, like parking space that was like…right next to the entrance, but to the stairs. And so, I guess the designers are like, oh, well it's right next to the entrance. But like the ramp was on the other side of the parking lot. So it's like, you kind of see what they were trying to do, but they just totally missed the mark. And all I could think about was when I was looking at this picture, I was like, well, if they just had like more diversity in their group and just more perspectives, this issue could have been easily rectified, but this was just so careless. And so I think like when they share these STS thinking skills with us, one of them being listening contextually, it will then help motivate us to like seek out different perspectives to them, like actually be effective in what we do."

Here, Imani highlighted the power of the STS Thinker Skill *Listening Contextually* for understanding different perspectives in human-centered design. Within Imani's storytelling is a broader critique about the harm that well-meaning design teams can do, and that "effective" design must involve the voices and perspectives of the people whose needs are being centered. Imani takes a strong moral and action-oriented stance toward the need to construct design teams with diverse representation and perspectives. While we acknowledge that inclusion, alone, will not lead to just outcomes without a focus on power, it is a necessary precursor to human-centered design. Jordan lodged a similar critique when storytelling about a moment from high school:

> "I think that was more of to get us to think about how just places are designed in general. And while doing it, it made me think of a specific time back in high school, where we invited a guest speaker to come to our school. And he was wheelchair bound. And my high school in particular didn't have a ramp to get up to the stage, so he had to speak from the floor of the auditorium. And so, that's what it really made me think back to, and how we need to make sure that, I guess it could kind of tie into engineering and make us think about when we're designing a system or designing anything really, that we need to be able to consider all perspectives."

Like Imani, Jordan recognized that human-centered design requires the consideration of diverse perspectives. He sees this moment of injustice as critically tied to the work of engineers, who he deems as partly responsible for the inequities designed into this system.

2. Making the invisible visible

As we have already begun to see in the previous section, course activities and STS Postures helped make salient otherwise taken-for-granted aspects of designed artifacts and environments. Students reported that these "aha" moments, where they began to unpack the often invisible ways that power operates in systems, as impactful for their learning. For example, Vanya said, "One of the biggest things that stood out to me is like, oh yeah…we really are talking about people and not just like numbers." Here, Vanya highlights the tendency for engineers to treat people as numbers, which assumes that people are fungible by stripping away basic aspects of humanity and obscuring their unique needs. This practice is so naturalized within engineering

and design that it can easily be taken for granted as completely sensible and possibly even desirable. Thus, one objective of the STS program is to disrupt these narratives and emphasize the importance of recognizing people's humanity within design.

Part of this process involved engaging students in *systems analyses* of mundane spaces. For example, as a primer to the *Community Futures Assignment*, time was provided to students during a virtual class session to gaze at a *photograph* by Andreas Gorsky of a 99 cent store that takes an elevated perspective on a mundane feature of everyday life in the United States [42]. One student, Carol, noted how powerful it was to see the conversation about the photograph progress from the simple act of observing to analyzing the broader systems in which the store was embedded. She recalled,

> "One of the interesting things was we did a whole assignment about this picture of a grocery store, and we had to break down different elements of that picture that would show like different parts of community, how they interact with community, how, um, the community is affected by it. And it was, I think, a ninety-nine cent store…I think we ended up getting into people living in poverty, and how they would rely on a store like that. And I think it's just really interesting seeing the way that the discussion goes…from something like normal observations, like oh, it's super colorful, there's food here, there's, um, school supplies here, and then ending up in a discussion about how this store affects people who are living in poverty is just kind of mind blowing."

This example shows how *data collection* and *analysis techniques* enabled deeper insights into how larger structural inequities, like poverty, functioned in mundane community spaces. Visual information interpreted together is a way of building expansive thinking and collaboration. By taking ample time to look at and generate observations about a single photo, students were able to build a shared environment of trust through which they could have conversations about how people in the community might use, navigate, and influence the space, an important precursor to human-centered design.

One student, Vanya, reported that the *Stakeholder Interview Project* enabled her to see mundane artifacts and structures in a more critical light. Her stakeholder interview with a facilities management employee provided deeper insight into the importance of roads, which she had previously taken for granted. She said,

> "When you first look at roads, you're kind of like, ok, they're there, you know, I use them, I don't use them. I walk across them, I drive on them. But then once you take that deep dive and look at it from different perspectives and using different research methods, whether it's like interviews on how other people feel about them in that kind of thing, you kind of start piecing together the puzzle of like, ok, there's this road, but there's such a bigger picture that this road is part of."

The data collection technique, *interviewing*, in combination with *analyzing a taken-for-granted artifact* from the perspective of the stakeholder, helped to recontextualize a resource that Vanya utilized every day and enabled her to see it as deeply connected to social, cultural, and political systems. This is a first step to understanding how roads work (or critically, don't) for people and communities.

Students were also provided with *textual documents* that introduced them to new ideas and supported powerful insights about human-centered design. For example, as part of the

Infrastructure and Disability Audit, students read an article about techno-ableism and techno-optimism [48]. Carol remembered this activity as incredibly powerful for helping her see that "the way that we (society) deal with people with disabilities is to give them technology, to make them more like us. And that was really eye opening and I was like, yeah, that's completely true. Like…we don't consider how that might affect them. We only consider how they affect us." Here, Carol critiques the socioculturally accepted practice of designing assistive technologies that force people with disabilities to navigate an ableist world, rather than changing the world to be more universally accessible.

3. Taking agency in developing moral and ethical stances

Some of these insights or 'aha' moments prompted students to take strong moral stances against the injustices they saw and the designed systems that enabled them. For example, Imani spoke about an insight she had during the *Infrastructure and Disability Audit*,

> "Within America, just with our infrastructural system, which I just was totally oblivious to and how we're not, um, promoting accessibility to everybody. Um, like recently we were talking about people with physical disabilities and like people use wheelchairs and just the idea that we use technology as an excuse to like, say like, oh, we can fix you because you have this physical disability you're broken. And like, when I read that, I was like, oh my God, like, no, that's not right at all. Like you can't say that. Um, Like, uh, that's totally what some people think and people like they might, their heart might be in the right place when they develop technology, um, to serve this certain group of people. But like, it's just not, I don't think it's morally correct. And so STS like talked about ethics a lot and, um, just how you should strive to accommodate like people rather than Technology."

The realization that engineers function within a socioculturally accepted paradigm that treats people with physical disabilities as "broken" prompted Imani to take a strong moral stance, that this paradigm is "not right at all" and isn't "morally correct." Part of this stance involves the recognition that technologies are not value-neutral tools; they are used as "an excuse…to fix" people. She also sees nuance and complexity in these socio-technical systems, in that people who design technologies for people with disabilities can have their "heart in the right place" and still have the propensity to do harm.

Seeing designed systems from multiple perspectives and making the invisible visible also enabled students to see that they had the propensity to take action to change their communities. For example, Jordan talked about how multiple classroom activities helped him see the ways that people can be marginalized within designed spaces. He said,

> "We had a discussion on e-scooters at one point in the semester. And I thought it was interesting, especially me who hasn't been to campus yet. It really got to paint the picture of just the logistics around the university, and how, there's a word that we like to use. And it's marginalized. So how different groups and systems can be marginalized by a specific decision. And furthermore, another activity we did was when we roleplayed as a stakeholder. And so each of us were assigned a different person who's influential within the UMD community. and so we, going back to the stoke earlier, we, one of our, the beginning activity for one of our discussions was, we would assume that role and then we

> would, I guess role-play how to, working with each other, and it's like trying to figure out how to better, like the university culture for our students."

Seeing campus spaces as deliberately designed helped Jordan think about the ways that the decisions of stakeholders have the potential to impact how people are marginalized (or not) by those systems. Importantly, he started to see marginalization as something that people have the agency to change. Through the *body/mind practice of roleplaying (stoke*s*)*, Jordan internalized this agency, seeing himself and his peers as capable of "working with each other…trying to figure out how to better…the university culture for our students." We see evidence of Jordan and others applying these ideas beyond the confines of the classroom and at times even beyond the traditional STEM design contexts. For instance, Jordan later talked about how the moral imperative of "owning your impact" became salient as a lens for making sense of complicated world events.

In summary, these examples highlight how analytical approaches, data collection techniques, and body/mind awareness practices were foundational for students to engage in and recognize the importance of human-centered design. This happened through key course assignments and activities that put explicit focus on experiential learning that involves moving outside the classroom to examine socio-technical systems. Experiencing the world through multiple lenses and with multiple senses enabled them to engage in critique of socio-technical systems and fostered empathy and a sense of solidarity with others, key features in human-centered design. These course artifacts and routines within the STS community (e.g. discursive norms and STS Postures) combined with the symbolic meanings that have been negotiated around them – constitute the cultural practices of the STS community.

C. How ethics of care in the STS community supported ethics of care in human-centered design

We now illustrate our claim of a connection between ethics of care embodied internally in the STS community, as discussed in subsection A, and students' recognizing a need for ethics of care in human-centered design, as just discussed in subsection B. We recognize that embodying an ethics of care in the classroom does not unproblematically lead to expertise in embodying an ethics of care in human-centered design. Yet, we see the forms of relationality and care that are embodied in the classroom as lending stability to care ethics in students' emerging human-centered design work.

For example, Jordan described how important it was to "have a safe space to discuss with each other" that "encourages us to talk about issues that are in society." Similarly, Vanya recalled how the relationships students developed in the STS program made it easier to discuss difficult issues, like how racism relates to design:

> "I remember we had to talk about racism at some point in the first semester and like how it relates to design and stuff. So even though we're talking about social issues, we're still looking at it in kind of a design perspective. [Interviewer: How did that kind of conversation about racism play out in the course?] It was a difficult one. Everybody felt a little awkward talking about it just because it is such a touchy subject. But I think once we got into separate breakout rooms, at least with some people that we'd already worked with from the discussion, it felt a little bit easier to talk about it and express our opinions and like what we thought about how it reflects in design and in society."

Vanya attributed the ease of conversation and high levels of participation to the “sense of community” that had developed within the STS program. This was especially true for “difficult” and “touchy” issues that students felt “awkward” discussing.

Since one goal of the STS program is to enable critical conversations about how various systems of oppression are mechanized in and through designed socio-technical systems, it is important that students feel safe having these discussions with their peers. Vanya went on to say, “I'm going to be honest, there's a lot more participation in scholars and STS than there is in any of the other classes that I've had, just because I feel like since we're building a community, it's a lot easier for us to talk about stuff, even if it's still a little bit awkward at first.” For Jordan, Vanya, and many others, the foundation of trust and care built within the STS community enabled students to be open and honest with each other without fear of judgment. They knew that the instructors and other students wanted to hear their perspectives and would listen to them with empathy and compassion. ***This sense of safety and mutual trust set a necessary foundation for the risk-taking involved in imagining more just worlds.***

VI. Discussion & Conclusion

Though cultural practices are messy and challenging to infer and model from student interviews and classroom observations, our results indicate they play a role in cultivating socio-technical thinking mindsets. In this section, we’ll discuss how we are seeing cultural practices of the STS program tied to the three facets of the STS Postures–data collection techniques, analytical approaches, and body/mind practices. Then we will reflect on the implications of our findings for the challenges of studying programs designed to counter the dominant cultural paradigms of engineering schools.

In the STS program, learning becomes an immersive shared practice where students have agency to set the agenda; the instructors send the message that “you come with material, we’ll build on what you are coming in with.” Both students’ personal histories and their data collection work as part of class activities serve as the basis for joint meaning making. That way STS collaborations are about establishing trust and constructing a shared world. And the ultimate aim is for students to practice this modeled disposition in their projects for the program and in their daily lives outside the program.

Our data clearly show an uptake of cultural practices aligned with the STS Postures as indicated by the four ways that students talk about the STS pedagogy: Making the invisible visible, valuing multiple perspectives, encouraging student agency to make change and develop moral/ethical stances, and prioritizing human wellbeing (an ethics of care). However, this uptake is uneven and in some cases students struggle to connect different facets of the STS Postures. This unevenness emerges in two distinct ways.

First, with a few exceptions, students see STS community building practices primarily in terms of enacting an ethics of care drawing upon mind/body practices but not drawing upon the two other facets of STS Postures, data collection techniques and analytical approaches. We see this disconnect, for example in the way students talk about stokes. In the STS Postures framework, stokes are intended not only to help students feel comfortable working with each other (e.g.,

team-building, community-building) but are also to help students feel comfortable applying data collection techniques, and secondarily, applying analytical skills in communities they design for. Despite instructors explicitly making this connection, students still mainly see stokes as community building activities. Sometimes students are confused by or even dismissive of their role. However, a few students feel empowered to "make it [the program] their own," exhibiting the tendency to embrace student agency to bring their own knowledges to the table.

Second, all four themes emerge from student perspectives on STS projects and assignments, especially human-centered design. In these examples, the value of data collection and analytical approaches (STS Thinker Skills) are highly involved in their thinking, but a deep connection to the body/mind facet is less explicit—despite the STS instructors' frequently exhortations that humans' ability to analyze (analytical approaches) data (data collection techniques) gets filtered through our mind/bodies. This disconnect is important because the body/mind awareness techniques are foundational for students to become fluid travelers between taking insider and outsider perspectives. For example, emotional regulation (e.g., recognizing cognitive distortions) is a grounding force for distinguishing self thoughts from those of others. Orientation/reorientation, specifically the metacognitive tendency to constantly evaluate when reorientation or orientation is happening, plays a similar role in helping students monitor and switch between different perspectives.

Understanding these disconnects is instructive for those wishing to build programs that counter the status quo of engineering culture. These disconnects likely arise for multiple reasons. As we established up front, cultural change is difficult. Much previous work suggests that students need time to wrestle with mindsets and practices that challenge the status quo (e.g., [8], [10], [13], [18], [49]). The current study is a snapshot of student experiences in the first year of a two year program. Furthermore, the STS program is only one cultural sphere among many (e.g., core courses in the engineering school, clubs, homelife, etc.) shaping students' college experiences. Some of these cultural spheres are in tension with one another. In particular, messaging from the STS program competes with cultural cues students receive in their engineering courses or from the broader U.S. neoliberal cultural milieu [21]. Cultural cues from the corporate context pervade students' imaginaries (visions of possible futures) about the role technology should play in society, where a form of technical narrowness manifests in dehumanizing and one-dimensional characterization of people as consumers [20]. Within this milieu, decision-making is viewed as a rational, data-driven endeavor divorced from body/mind awareness and human well-being more generally. Likewise, in most engineering schools, a focus on technical awareness creates a culture of disengagement and depoliticization of technology and engineering solutions [12], which encourages a distanced rationalism—the epitome of mind/body separation that leads to indifference about the unintended consequences of technological development. So in many ways, the deck is stacked against STS programs designed to encourage macro-ethical thinking in which body/mind awareness is deeply connected to—or even part of—data collection techniques and analytical approaches. Nonetheless, our results suggest that change is possible. However, we should adjust our expectations to long-term incremental change. Working from the inside requires patience. Change happens in fits and starts.

We would like to end with a note of caution. In any attempt to make change we run the risk of being just as socially harmful as the dominant cultures we are trying to change. Developing

macro-ethical practices and mindsets needs to be achieved without oppressively pushing our own ideology on students. It is important that students feel that they have agency to question the pedagogy of immersive countercultural engineering programs emphasizing macro-ethics. We need to model what we advocate, inviting students as partners of change. The work of these programs is to help students see the need for change and let them make up their own minds. This involves, as illustrated above, creating opportunities for students to go out in the world, bring back critical observations, and then draw on those experiences and observations to ground in-class and out-of-class discussions. Critiques of society should therefore emerge from those embodied experiences. These types of experiences require deliberately designed scaffolded experiences that generate critical conversations about society as authentic encounters that are fun and joyful.

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References

[1] N. S. Nasir and B. Kirshner, “The cultural construction of moral and civic identities,” *Applied Developmental Science*, vol. 7, no. 3, pp. 138–147, 2003, doi: 10.1207/S1532480XADS0703_4

[2] G. J. Kelly, “Inquiry, activity, and epistemic practice,” in *Teaching scientific inquiry: Recommendations for research and implementation*, R. A. Duschl and R. E. Grandy, Eds., Rotterdam: Sense Publishers, 2008, pp. 99–117.

[3] H. B. Carlone, “Methodological considerations for studying identities in school science: An anthropological approach,” in *Identity construction and science education research: Learning, teaching, and being in multiple contexts*, M. Varelas, Ed., The Netherlands: Brill, 2012, pp. 7-25. doi: 10.1007/978-94-6209-043-9_2

[4] H. Han and J. Changwoo, "Improving epistemological beliefs and moral judgment through an STS-based science ethics education program," *Science and Engineering Ethics,* vol. 20, pp. 197-220, 2014.

[5] J. R. Herkert, “Ways of thinking about and teaching ethical problem solving: Micro-ethics and macroethics in engineering.” *Science and Engineering Ethics*, vol. 11, no. 3, pp. 373–385, 2005, doi: 10.1007/s11948-005-0006-3

[6] J. R. Herkert, “Confession of a shoveler: STS subcultures and engineering ethics,” *Bulletin of Science, Technology and Society*, vol. 26, no. 5, pp. 410-418, 2006.

[7] L. Claris and D. M. Riley, “Situation Critical: Critical Theory and Critical Thinking in Engineering Education,” *Engineering Studies*, vol. 4, no. 2, pp. 101-120, 2012.

[8] E. A. Cech, “The (mis) framing of social justice: Why ideologies of depoliticization and meritocracy hinder engineers’ ability to think about social injustices,” in *Engineering education for social justice: Critical explorations and opportunities*, J. Lucena, Ed., vol. 10. Dordrecht: Springer, 2013, pp. 67-84.

[9] D. Nieusma, “Conducting the instrumentalists: a framework for engineering liberal education,” *Engineering Studies*, vol. 7, pp. 159–163, 2015.

[10] J. A. Leydens and J. C. Lucena, *Engineering justice: Transforming engineering education and practice*. Hoboken, NJ: John Wiley & Sons, 2017.

[11] A. R. Bielefeldt and N. E. Canney, “Social Responsibility Attitudes of First Year Engineering Students and the Impact of Courses,” in *Proc. ASEE Annu. Conf. and Expo.*, Indianapolis, IN, USA, 2014.

[12] E. Cech, “Culture of Disengagement in Engineering Education?” *Science, Technology, and Human Values*, vol. 39, no. 1, pp. 42-72, 2014.

[13] N. Canney and A. Bielefeldt, "A framework for the development of social responsibility in engineers," *International Journal of Engineering Education*, vol. 31, no. 1B, pp. 414-424, 2015.

[14] B. Newberry, “The Dilemma of Ethics in Engineering Education,” *Science and Engineering Ethics*, vol. 10, no. 2, pp. 343–351, 2004.

[15] D. Riley, 2013. “Power. Systems. Engineer. Traveling Lines of Resistance in Academic Institutions.” in *Engineering Education for Social Justice*, J. Lucena, Ed., Dordrecht: Springer Netherlands, 2013, pp. 41-63.

[16] A. Bandura, “Social cognitive theory of self-regulation,” *Organizational Behavior and Human Decision Processes*, vol. 50, no. 2, pp. 248-287, 1991.

[17] D. Hart, R. Atkins, and D. Ford, “Urban America as a context for the development of moral identity in adolescence,” *Journal of Social Issues*, vol. 54, no. 3, pp. 513–530, 1998.

[18] G. L. Downey, (2015). “Opening up engineering formation,” *Engineering Studies*, vol. 7, no. 2–3, pp. 217–220, 2015, doi: 10.1080/19378629.2015.1121612

[19] M. Lachney and D. Nieusma, “Engineering bait-and-switch: K-12 recruitment strategies meet university curricula and culture,” in *Proc. ASEE Annu. Conf. and Expo.*, Seattle, WA, USA, 2015.

[20] J. Radoff, C. A. Turpen, F. N. Abdurrahman, D. Tomblin, A. Agrawal, D. Chen, S. Chudamani, “Examining the “narrow” and “expansive” socio-technical imaginaries influencing college students’ collaborative reasoning about a design scenario,” in Proc. ASEE Annu. Conf. and Expo., Minneapolis, MN, USA, 2022.

[21] F. Abdurrahman, S. Chudamani, C. Turpen, J. Radoff, A. Elby, D. Tomblin, “How Students Reproduce Technocratic Reasoning in Collaborative Design Work,” in Proc. ASEE Annu. Conf. and Expo., Baltimore, MD, USA, 2023.

[22] A. Pickering, *The Mangle of Practice: Time, Agency and Science*. Chicago, IL: University of Chicago Press, 1995.

[23] J. Law, *After Method: Mess in Social Science Research.* New York, NY: Routledge, 2004.

[24] N. Mogul and D. Tomblin, “STS Postures: Changing How Undergraduate Engineering Students Move Through the World,” in Proc. ASEE Annu. Conf. and Expo., Minneapolis, MN, USA, 2022.

[25] R. Volti, *Society and technological change*. New York, NY: Worth Publishers, 2014.

[26] S. Sismondo, Introduction to Science and Technology Studies. West Sussex, UK: Blackwell Publishing Ltd., 2010.

[27] A. Gupta, “A practitioner account of integrating macro-ethics discussion in an engineering design class,” in *Proc. ASEE Annu. Conf. and Expo.*, Columbus, OH, USA, 2017.

[28] D. M. Riley, *Engineering and Social Justice*. San Rafael, CA: Morgan and Claypool, 2008.

[29] J. A. Schumacher, *Human Posture: The Nature of Inquiry*. New York, NY: SUNY Press, 1989.

[30] G. Downey and T. Zuiderent-Jerak, “Making and Doing: Engagement and Reflexive Learning in STS,” in *The Handbook of Science and Technology Studies*, U. Felt, R. Fouche, C. A. Miller, and L. Smith-Doerr, Eds., Cambridge, MA: MIT Press, 2017, pp. 223–252.

[31] E. York, “Doing STS in STEM Spaces: Experiments in Critical Participation,” *Engineering Studies*, vol. 10, no. 1, pp. 66–84, 2018.

[32] E. York and S. N. Conley, “The STS Futures Lab at the Intersection ofResearch and Pedagogy,” in *Proc. Annual Meeting of the Society for Social Studies of Science*, New Orleans, LA, USA, 2019.

[33] E. York, and S. N. Conley, “Creative anticipatory ethical reasoning with scenario analysis and design fiction,” *Science and Engineering Ethics*, vol. 26, pp. 2985-3016, 2020.

[34] D. Tomblin and N. Mogul, “STS Postures: responsible innovation and research in undergraduate STEM education,” J. of Responsible Innov., vol. 7, no. 1, pp. 117-127, 2020.

[35] M. Foucault, *Power/knowledge: Selected interviews and other writings,* C. Gordon, Ed., New York, NY: Pantheon Books, 1980.

[36] A. Feenberg, *Alternative Modernity: The Technical Turn in Philosophy and Social Theory*, Berkeley, CA: University of California Press, 1995.

[37] L. Winner, “Do artifacts have politics?” *Daedalus*, vol. 109, pp. 129–136, 1980.

[38] S. Harding, *Is Science Multicultural? Postcolonialisms, Feminisms, and Epistemologies.* Bloomington, IA: University of Indiana Press, 1998.

[39] J. Dumit, “Writing the Implosion: Teaching the World One Thing at a Time,” *Cultural Anthropology*, vol. 29, no. 2, pp. 344-362, 2014.

[40] G. Lakoff, and M. Johnson, *Metaphors we live by.* Chicago, IL: University of Chicago Press, 1980.

[41] E. Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*. New York, NY: Cambridge University Press, 1990 (2008 reprint ed.).

[42] https://www.thebroad.org/art/andreas-gursky/99-cent

[43] D. Holland, W. Lachoite, D. Skinner, and C. Cain, *Identity and agency in cultural worlds*. New York, NY: Cambridge University Press, 1998.

[44] C. A. Turpen, J. Radoff, K. Adkins, S. R. Bikki, K. Z. Rahman, and H. Sangha, “Partnering with undergraduate engineering students to unearth cultural practices within a Science, Technology, and Society (STS) program,” in Proc. ASEE Annu. Conf. and Expo., Minneapolis, MN, USA, 2022.

[45] N. Noddings, *Caring: A Feminine Approach to Ethics and Moral Education.* Berkeley, CA: University of California Press, 1984.

[46] M. Nussbaum, “Human Rights and Human Capabilities,” *Harvard Human Rights Journal*, vol. 20, pp. 21-24, 2007.

[47] D. Riley, *Engineering and Social Justice*. Morgan & Claypool Publishers, 2008.

[48] A. Shew, “Different Ways of Moving Through the World,” *Logic*, vol. 5, pp. 207-213, 2018.

[49] N. A. Andrade and D. Tomblin, “What Are They Talking About? Depth of Engineering Student Sociotechnical Thinking in a Technical Engineering Course,” in Proc. ASEE Annu. Conf. and Expo., Tampa, FL, USA, 2019, doi: 10.18260/1-2--33551.