

Partnering with undergraduate engineering students to unearth cultural practices within a Science, Technology, and Society (STS) program

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I. Introduction

In many orientations to social science research, study participants are positioned as objects of inquiry, but are not treated as partners in the inquiry process or within knowledge development processes. This paper offers one account of an engineering education research team disrupting this dichotomy between “researcher” and “researched.”

This work takes place in the context of an NSF-funded ethnographic investigation of University of Maryland (UMD) College Park Scholars Science, Technology, and Society Living Learning Community (STS-LLC) [1]. Our investigation focuses on understanding how engineering students’ macro-ethical reasoning develops within the cultural practices of this community [2-5]. In our approach to this investigation, we deliberately partnered faculty research leads and a group of undergraduate research fellows (URFs) who were chosen based on their “insider” status within the STS-LLC cohort being investigated [6, 7]. This team worked to create a community of scholars across these varying institutional positionalities that engaged in the inquiry process together.

Building such a collaboration required creating substantial infrastructure and routines for disrupting the usual hierarchies that exist between researchers and participants. This paper will share multiple perspectives, from both undergraduate research fellows (URFs) and research leads, on the mutually beneficial relationships that emerged within this research collaboration. We will draw on research team meeting notes, formative feedback survey responses, and narrative reflections from URFs to support our claims. Research leads also share their perspectives on recruiting, onboarding and working with the URFs and describe some of the macro-ethical considerations that motivated their partnership with URFs [4, 5].

Dr. Turpen and Dr. Radoff, the research leads, and a subset of URFs (K. Rahman, S. Bikki, K. Adkins, and H. Sangha) collaboratively developed this paper. We organize our findings into three parts; we describe: (a) the multiple ways the research leads benefited from this collaboration, (b) the multiple ways the URFs have benefited from this collaboration, and (c) the joint work processes and routines within our research collaboration that likely supported these positive outcomes. We conclude by discussing particular socio-technical innovations that supported our effective co-learning and co-working processes. We intend for the detailed accounts of our joint work processes and routines to support other research teams in adapting such work processes to their own contexts.

II. Study Context

II.A. The Science, Technology and Society (STS) Honors College

The setting for this investigation is a STS Honors program sponsored by the College of Engineering at University of Maryland, College Park. This program is typically a living-learning community where students live within the same dormitory across the first 2 years of the program.

However, this study took place during the Covid-19 pandemic. To mitigate health risks and adapt to the pandemic conditions, only a small fraction of the students lived on campus during the first year of this study. Most students remained at home with their parents or guardians and attended school entirely remotely.

Overall this STS program seeks to counteract the narrow focus on technical preparation many students encounter within college engineering and science degree programs. The program focuses on cultivating social constructivism [8, 9, 10] and supporting macroethical reasoning within its students [2-5]. All STS students take two “colloquium” courses in the first year of the program. To give you a feel for what these colloquia are like, here are some excerpts of a memo written by the program director, Dr. David Tomblin, on how power came up in the first colloquium course:

Students conducted a semester-long project examining how COVID-19 impacted the campus and local community. This was an opportunity to see how power is distributed within a local community. In teams, students interviewed approximately 30 stakeholders in the community to identify how the pandemic influenced them. This data was analyzed to identify problems that needed to be addressed within the community. We used several STS concepts and analyses to look at the data from a variety of perspectives to understand how power is unevenly distributed within communities. We looked for structural influences of power on communities.

In the second year of the program, students enroll in STS ‘practicum’ courses that are designed to provide students with service-learning and field experiences focused on community engagement. The STS program experience concludes with a capstone course where students synthesize their STS learning to pursue sustainability projects with global partners. See [1] for more information about key foothold ideas that students are introduced to in this program and the organizing principles behind this program. The STS program, through its directors, instructors, and other support partners, embodies certain values, goals, practices, and knowledge bases that laid the foundation for our study and for the collaborative work we sought to accomplish in our research collaboration.

II.B. Introducing our investigation of cultural practices for supporting ethical engineering

Our research collaboration took place within the context of a larger NSF-funded research study. This study is exploring whether and how extended immersion in cultural practices of the UMD STS-LLC program supports students’ macro-ethical sense-making about the world and exploration of their personal and professional ethical responsibility within it [4-5]. The primary orienting research question in our broader investigation is, “How do activities in a multi-year living-learning program with an STS emphasis help shape engineering students’ development of macro-ethical perspectives and participation in macro-ethical practices across multiple contexts over time?” For our team, macroethics involves attending to issues of social justice and the ways in which sociotechnical dilemmas are entangled with social, political, economic, and environmental considerations [2-5].

Our approach to this research study integrates “outsider” (researcher leads’) and “insider” (participating students’ and URFs’) observations of and reflections on culturally salient events, activities, and artifacts to create ethnographic accounts [6-7] of cultural practices [11-12] that are consequential for shaping engineering students’ macro-ethical reasoning and identity. In our study, we follow one cohort of STS students longitudinally over two years of the STS-LLC program and develop accounts of how individuals do and do not take up STS-LLC cultural practices and bring elements of those practices into other settings. We have conducted interviews with participating students at multiple points over the last two years to learn about students’ backgrounds and experiences in the program, conducted focus group interviews where students collaboratively reasoned about complex design scenarios, and collected ethnographic observations across many STS courses.

II.C. Our design logic and broad structure of our research collaboration

As research co-leads, Dr. Turpen and Dr. Gupta began by generating a list of orienting values to guide our research collaboration including that students should gain value through their involvement in the research process, and that we should:

- prioritize students from marginalized backgrounds in selection of student researchers,
- produce non-deficit accounts of students and the STS program by stretching our explanations across systems and structures,
- contest authoritarianism,
- learn from and try to adopt anti-racist and anti-sexist ways of working with one another and with ourselves, and
- embody ethics of care within our team.

In designing our research collaboration, we worried that ‘training’ students in the professional vision of ethnographic research might constrain what they see, and prevent them from developing insights from the vantage point of their own experiences. As a result, we brainstormed ways to help students develop expertise in bringing a cultural lens to their observations, to become skilled at seeing cultural practices around them, rather than narrowing their focus only on what we went in planning to study. We drew from Carlone’s work [13, 14] in designing protocols and onboarding activities for our team. We realized that these practices of cultural analysis overlapped with some of the orienting goals of the STS program and competencies it was trying to cultivate. For example, Dr. Gupta had observed an STS lesson where the instructor invited students to photograph the contents of different refrigerators they had access to (at home and at work) and then analyze those scenes. In a research meeting, Dr. Gupta noted that, “these activities prepare them to take up cultural analysis.”

At the 2020 Physics Education Research Conference, Dr. Turpen had the pleasure of meeting Dr. Trenton Marsh in an invited session [15]. In this session and associated discussion spaces, Dr. Turpen learned about Trenton Marsh’s powerful ethnographic investigations of youth of colors’ perspectives on what “success” means within a “no-excuses” public charter school setting [16]. Dr. Marsh’s approach, drawing on photovoice methodologies [17-18], emphasized co-producing research with young people guided by principles of power-sharing, transparency, vulnerability, and trust-building. He described enabling youth to co-construct possibilities for social action [16, 17]. Dr. Marsh described his own ethical orientation to his research work as centrally orienting to

affirming young people’s experiences and supporting them as full human beings. He argued that it was an important accomplishment to create spaces where this is possible. He asserted that, “Life is better in that space of hope.” He saw this form of research as a way to both “fight the fight” and “take care of myself.” As Dr. Turpen described our study context and explored with Dr. Marsh possible ways to partner with youth in the context of this study, Dr. Marsh advised, “If you want to build an interactive community... get them to speak to each other as much as possible.” Following these discussions, Dr. Turpen wrote extended reflections on how this might inform the design of the STS research collaborations.

II.D. Research fellow recruitment, selection and scope of work within specific project phases

With these questions and values in mind, we dove into recruiting and hiring URFs. Primary data collection for the project began in the Fall of 2020, with research leads collecting field notes in the colloquium courses, where all first year STS students were enrolled. The first cohort of URFs was recruited in the Spring of 2021. Fifteen students from our study cohort applied, and all were accepted into the fellowship. Of these fifteen URFs, all were invited to apply to the Summer 2021 fellowship. Eight of the fifteen applied and all eight were accepted into the Summer 2021 fellowship. All fifteen of the original URF cohort were once again invited to apply for the Fall 2021 fellowship (plus one additional student who expressed interest to STS instructors in securing paid research work). Eleven students applied, and ten were accepted into the fellowship.

The Spring and Fall URFs collected field notes [19] in three different STS ‘practicum’ courses, that were designed to provide students with service-learning and field experiences focused on community engagement. URFs were divided into three ‘data teams,’ with each data team observing a different practicum course. A subset of the URFs on each data team were enrolled as students in the course and were tasked with writing firsthand reflections after each class. URFs who weren’t enrolled as students attended classes as observers, and were tasked with collecting ethnographic field notes. This structure enabled enrolled URFs to fully participate as students in the course without having to divert their attention to data collection. Simultaneously this model still allowed enrolled students to contribute to developing interpretations and analyses of the course, by writing reflections and contributing to ‘multivocal’ field notes (which we elaborate on in later sections). Time was set aside during our weekly research team meetings for data teams to meet and discuss salient moments and events observed.

Since no STS courses met during the summer term, the Summer URFs focused mainly on engaging with the engineering education research literature as well as processing and analyzing interview and focus group data that were collected by research leads during the Spring of 2021. In particular, they were tasked with editing interview transcripts and analyzing these transcripts from multiple lenses. They collaboratively developed annotations and summaries of the articles they were reading. They produced memos analyzing transcript data from a personal lens, a political lens [20], an analytical lens (informed by methods in [21]), and practiced using conceptual and theoretical constructs from engineering education literature [1, 5, 22-24].

Table 1: URF responsibilities during different project phases

Project Phase	Primary URF Responsibilities	Number of URFs
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Phase 1: Spring 2021	Writing reflections, conducting virtual observations, writing field notes [19], and building interpretations	15
Phase 2: Summer 2021	Processing and analyzing focus group transcripts, Engaging with Eng. Educ. literature [1, 5, 21-24]	8
Phase 3: Fall 2021	Writing reflections, conducting observations in-person, writing field notes, and building interpretations	10
Phase 4: Winter 2022	Continuing analysis, developing claims, outlining paper story arches, and writing paper sections	7

Over the duration of the project, this research collaboration engaged six senior researchers and sixteen unique URFs. The co-authoring team on this paper includes two senior researchers that led the mentorship of URFs (Dr. Turpen and Dr. Radoff) and four URFs from different phases of our collaborative work. All URFs were invited to participate as co-authors on this paper, if they had the capacity to contribute to collaborative writing activities during January 2022. Our co-authoring team includes some URFs that have been part of the research team across all phases of the project (K. Rahman and S. Bikki), another who joined the project in phase 3 (K. Adkins), and another who participated in phase 1, stepped back, and then rejoined the team at phase 4 (H. Sangha). Three other URFs, who participated in all 3 phases, are co-authors on another 2022 ASEE conference paper submission [25].

III. Conceptual Framework

This paper draws from the lens and assumptions of three bodies of work: (1) participatory action research, (2) sociocultural perspectives on learning within undergraduate research experiences, and (3) design-based research.

Our orientation towards engaging undergraduates in research work was informed by approaches like participatory action research (PAR), which invites people (often youth) from disenfranchised groups into collaborative knowledge building by drawing on educational research tools to investigate problems that impact their daily lives. While there are some differences—like the extent to which student researchers have control over defining the core goals and methods of the study—there are ways in which traditions like PAR have influenced the commitments, practices, and ethos of our undergraduate research fellowship. For instance, Rodríguez & Brown describe three guiding principles for participatory action research with youth: (1) *situated and inquiry based*, where the research is situated within settings where youth co-researchers live and learn and is focused on developing a critical awareness of how power operates in those settings, (2) *participatory*, in which youth are engaged as genuine partners in the research, from influencing the nature and direction of the inquiry to connecting analyses rooted in their personal experiences to more formal theories and scholarship, and (3) *transformative and activist*, where research is aimed at improving the lives of marginalized youth, by transforming oppressive structures [26]. These principles exemplify an ethos of care and mutual respect, where youth co-researchers are engaged in “learning and inquiry—not as information receptacles or data sources but as whole

human beings...they must have learning experiences that are purposeful, supportive, practical, and analytically rich and that promote justice and liberation” [26, p. 25]. We draw from this ethos in our work with undergraduate researchers, who we intended to engage in ways that not only provided enrichment and support in the present, but that they could carry with them to transform their futures and create new possibilities for collective action.

In our approach to this research, we seek to better understand how possibilities for learning and becoming in this space are shaped by the social organization of specific settings and nested contexts [27, 28]. This approach to modeling learning draws centrally from a sociocultural perspective on learning [6-7, 29]. Consistent with a sociocultural perspective on learning, this paper draws from theoretical and analytical approaches developed by Quan et al. [30] for making sense of undergraduate students’ learning within early research experiences in the physical sciences. In Quan’s foundational work, they built off of the scholarship of Michael Ford who theorized about the value of centering “scientific practices” as an organizing construct in designing learning experiences for science learners [31]. Ford’s work importantly articulated how practices (as cultural phenomena with cultural meanings) were much more than “skills,” as they are often taken up in science education [31]. He focused on modeling how students engaging in scientific inquiry can come to see or experience specific scientific tasks and activities as connected, purposeful and prospective within some community sphere – constructing them as scientific practices [31].

Quan et al. [30] extended Ford’s model to studying how undergraduate students embedded in early research experiences in physical science research labs came to see their work as “purposeful” and “connected” in varied ways. In this model, they introduce a first domain called “Relational Dynamics” which encompasses the social organization of the setting. This domain includes aspects of personal relationships and forms of joint work, such as the project’s form and structure and patterns of interactions between community members. In this model, they introduce a second domain called “Features of Disciplinary Practice” which captures the primary outcomes of interest in their investigation – specifically the development of scientific practices as purposeful and connected. Importantly, these two domains of investigation are seen as coupled, so the social organization of the setting is modeled as consequential for what people learn within that setting.

In adapting and extending this model to our study context, we seek to investigate: (a) the social organization of the setting, (b) what outcomes team members experience, and (c) in what ways the URFs, who are relative newcomers to social science research, come to see their research practices as purposeful, connected, and prospective within a scholarly community.

In Quan et al.’s prior work [30], the outcome space was limited to the development of scientific practices as purposeful and connected. In our current work, we expand our focus to capture a broader sense of possible outcomes, benefits, or value that can emerge for team members from these research collaborations. In particular, we were inspired by the work of Nussbaum [32] as well as Leydens and Lucena [33] to think broadly about how our research collaboration impacted human rights and capabilities (e.g. life, bodily health, bodily integrity, the development and expression of senses, imagination and thought, emotional health, practical reason, affiliation, relationships with others, play, and control over one’s environment).

Our approach in this paper is also informed by design-based research [34-38]. In design-based research (DBR), scholars are striving to model how the design of a learning environment is consequential for the forms of participation and engagement that emerge in that setting (e.g. design conjectures) [38]. Additionally DBR scholars seek to build claims about how those forms of participation and engagement lead to particular outcomes (e.g. theoretical conjectures) [38]. To state this more colloquially, a DBR approach strives to build knowledge claims in two forms: (1) when we organize things this way then we expect to see these things happening and (2) when these things are happening we expect to see these outcomes. Though this paper will not fully state concrete design conjectures and theoretical conjectures as a complete design-based research study would, this paper does lay important groundwork for a more extensive design-based research study in the future. As such, in this paper, we focus on describing: (a) early design logic and heuristics (see section II), (b) emergent forms of joint work (see section VII), and (c) observed outcomes (see section V & VI).

IV. Methods and Analytical Approach

Our analysis relied on multiple artifacts from our team's joint work as primary data sources including: (a) detailed records from meeting notes from research leads' project planning meetings, (b) detailed records from meeting notes from our collaborative research team meetings, (c) formative feedback surveys from URFs, and (d) reflective memos from research team members. We will talk about each of these data sources briefly, in turn.

The research leads' perspectives on the design logic and experiences of participating in the research collaboration drew heavily from project planning meeting notes – where we discussed pros and cons of various designs and pragmatic routines for our team, and where we described our logic for partnering with students over different phases of the project. These records captured some of the macro-ethical considerations that motivated our partnership with URFs in the context of this investigation, particularly during the pandemic times. We also deliberately video recorded a “debrief” between the research leads immediately following our intensive collaborative work with URFs over the summer. The transcript of this conversation (along with project planning meeting notes) served to guide and structure the research leads' memoing. These data sources supported the research leads in building accounts of joint work processes and a range of benefits experienced (by them, the URFs, and the project holistically).

Initial data sets for understanding the experiences of the URFs within the research collaboration were derived from URFs' responses to formative feedback surveys administered at the end of each project phase. During the Spring 2021 and Summer 2021 project phases, these short surveys asked URFs to respond to three prompts:

- Q1) Some aspects(s) of the research fellow experience that worked well for me are...
- Q2) Some aspects(s) of the research fellow experience that did NOT work well for me are...
- Q3) Some thing(s) that I'm wondering about (regarding this project and future URF experiences) are...

During the most recent Fall 2021 project phase, we expanded the set of survey prompts to solicit more detailed stories about the value that URFs recognized from these experiences as well as the collaborative work processes that may have enabled these outcomes. In addition to Q1, Q2 and Q3 above, we added the following questions:

- What have you valued about the ways that the research team collaborates?
- In what ways do you feel you have been able to influence or shape how our research team operates, and the insights developed in the research project?
- In what ways has your participation in this research team...
 - shaped your experience as a college student?
 - shaped your awareness and understanding of what the STS program is striving to accomplish?
 - contributed to building your awareness of culture and the subtle ways that meanings are built up in various settings?

These brief surveys were an extremely valuable source of information about a larger set of URFs' experiences with the role, as the surveys had response rates of about 66% on average.

Our secondary data set for making sense of the URFs' experience within the research collaboration were personal memos written by URFs. In advance of writing these memos, co-authoring URFs and the research mentors had a synchronous meeting where they collaboratively brainstormed about the valuable aspects of the research collaboration. The group was asked to brainstorm around the following prompts: "How have you been impacted and/or transformed by the URF role? How have you benefited from the URF role? What do you value about how we work together?" After some independent brainstorming and joint discussion, the co-authoring URFs wrote personal memos with this paper development in mind. Each person's independent memo was largely guided by the same prompts (stated above). We also invited other URFs (who did not have capacity to be involved in co-authoring this paper) to write memos on these topics to inform this paper development. One additional URF wrote and shared a memo with us. This paper drew from the data set of these five extended memos.

Analysis of these data sources was pursued collaboratively by our co-authoring team. In our synchronous paper development meetings, we began by considering the set of personal extended memos written by URFs. All research team members read through one other person's memo. As they read, the readers worked to identify two things: (a) What impacts / benefits / values are coming up? and (b) In what ways were those benefits enabled or supported by particular structures or routines in our group? After collecting key phrases or sentences on both themes, we narrowed our focus onto joint work processes. We worked together to identify some natural groupings of things that seem to relate, aiming for three to five bins of things we might want to talk about in the paper. Through this discussion, we developed the six categories of work processes presented here:

1. Clear expectations and shared documentation practices,
2. Writing practices for developing ideas,
3. Affordances of the observing role,
4. Reliance on multiple modes of expression,
5. Meaningful exchange of ideas in meeting discussions, and
6. Continuities between the STS program and the research collaboration.

Various co-authors led the initial drafting of description of the meaningful and consequential work processes based on the accounts in the available research team memos. The purpose of these “work processes” memos was to tell a detailed story about what a particular set of work processes, norms or joint work looked like in practice, so another research mentor or research team could emulate what we did (if their values and goals aligned). In our analysis, we also paid attention to the ways in which URFs experienced social science research practices to be purposeful, interconnected and prospective [30].

Following our initial drafting of consequential joint work processes, our co-authoring team returned to the formative feedback survey responses. Our team read through URFs survey responses to identify additional topics related to (a) benefits, valued experiences, or impacts, and (b) consequential joint work processes. Our team examined URFs survey responses to see if there were important work processes to add into our written accounts of our joint work processes. Our next analysis task was to develop similar “natural groupings” for the set of benefits, valued experiences, or impacts experienced by URFs. In developing these categories, our team drew from both the extended personal memos from URFs and URFs’ survey responses. After substantial discussion and consideration of multiple possible categorization schemes, we converged on the categories presented here:

1. Professional development in social science research practices,
2. Personal transformation,
3. Academic development, and
4. External connections.

As we wrote and externalized stories about each category, we tinkered with the category labels.

V. Research Leads’ Accounts of Mutual Benefit

For the research leads, there were many benefits to inviting undergraduate students into the research work. These benefits include increasing students’ access to opportunities and resources, enhancing students’ human capabilities, generating more robust interpretations and knowledge claims, expanding our team’s capacity for collecting data across many settings, and cultivating healthy and meaningful relationships between a community of scholars.

V.A. Increasing students’ access to opportunities and enhancing students’ human capabilities

Over the last few years, the Engineering Education Research Group and STS Program leaders have regularly conversed and mutually supported one another. This community met semi-regularly over the Summer of 2020 to process the pandemic, consider its influence on our lives and our communities, and envision new activities for the STS program. The pandemic made it strikingly clear to us the lack of social infrastructure for meeting people’s basic needs for food, health care, shelter, and utilities. We talked about the uncompassionate and inhumane expectations being placed on workers and the disregard for human life and wellbeing it reflected.

In writings after these discussions, one of our research leads noted, “recognizing my own privilege [and] questioning resource hoarding in our country.” This memo described how societal structures can serve to “obfuscate/make invisible these problems to many” people. This awareness shaped one research lead’s thinking about how STS Program activities could be

designed in the Fa20 semester to engage STS students in these issues. For example, she wrote, “how can we help highlight many students’ privileges and deep structural inequities in society. It makes me think about the tenets of STS-thinking and whether someone can make a lot of progress towards social constructivism, but still be largely blind to many systems of oppression.”

At the same time, Turpen was actively involved in the Access Network [39, 40, 41] which established and ran a community-sourced “emergency fund” [42]. Co-organizing with students and scholars within this Network made it clear to her that these conditions were greatly shaping the lives of college students. Turpen began reading research that documented the prevalence of food insecurity and housing insecurity facing college students before and during the pandemic [43, 44, 45]. This awareness shaped how she thought about reallocating grant resources on the STS project to support undergraduate students.

Discussions across these two communities shaped the project team’s thinking about creating and expanding the scope of opportunities available to undergraduate students to be involved in research, to be compensated for their work, and to giving students’ financial need consideration in our selection of research fellows. In these community discussions and written reflections, we also see evidence of us orienting to cultivating some “critical consciousness” in ourselves, those around us, and our undergraduate student research partners [26].

A top priority for the research leads was a values-based desire to make work opportunities available that supported the human rights and capabilities of undergraduate students, many of whom struggle to find paid work that aligns with their professional interests and goals. We also knew that the pandemic had created even more challenges to finding paid work, which many students needed to support themselves while they attended college. We were aware that the pandemic had also limited the opportunities for students to interact and form relationships with their peers, as most of their coursework moved online and many students chose not to live on campus. Therefore, it was a priority for us to create opportunities for students to work virtually, flexibly, collaboratively and to be fairly compensated for such work.

We hoped to provide an experience that was professionally, intellectually, and personally rewarding, that could meet URFs where they were at rather than engaging them in menial work or something too far outside of their realm of expertise for them to feel like they could meaningfully contribute. In other words, we wanted to “set them up for success” and hoped they would walk away from the experience feeling more knowledgeable and competent than when they arrived.

V.B. Generating more robust interpretations and knowledge claims

Another benefit the research leads recognized was working collaboratively with the URFs to shape the qualities of knowledge production. One of our goals was to engage them in many aspects of the research process, which spanned from data collection and audio transcription to literature review and analysis. Since we involved them as active knowledge-building partners, they contributed as such, shaping the way we interpreted the data, building knowledge-claims, and making meaningful connections to scholarship. Importantly, they provided an “insider’s view” of the study settings, which enabled the research leads to develop a deeper understanding

of norms and practices they wouldn't otherwise have access to. They provided a different lens and insight into the personal, institutional, and political value the work could offer [20]. They also played a central role in shaping discursive norms in our research meetings. They actively made space for one another to share ideas and experiences, and created a respectful and welcoming environment that enabled open, honest, and deeply personal discussions.

V.C. Expanding our team's capacity for collecting data across many settings

The URFs also supported and shared the labor of data collection and preparation, analysis, and interpretation. They enabled the project to collect data across many more settings than the research leads could handle on their own. They also provided invaluable feedback on one another's field notes and research products, which supported ongoing processes of reflection and revision. They enabled the research leads to develop analyses that were more holistic and far-reaching than they would have had the capacity to do on their own.

V.D. Cultivating healthy and meaningful relationships between a community of scholars

Finally, collaborating with the URFs was life-giving and energizing for the research leads and gave them a sense of deep purpose and excitement – within the project context and beyond. Seeing the work through the URFs' eyes pushed the research leads to make explicit and question some of the tacit assumptions they had been making, which ultimately supported a richer and more expansive research vision.

We, the research leads, value the relationships we built with the URFs. The social interactions we had with the URFs supported our meaningful engagement with macro-ethical dilemmas around us during a stressful and tumultuous time. During a time of overwhelm and stress for many, it was extremely valuable to have a sphere where we could deliberate about the complex ethics of these pandemic times [25]. We found the collaboration with URFs to be professionally, intellectually, and personally rewarding, which enhanced our human capabilities and led to personal transformation for us. The expansion of our own critical consciousness was a direct result of these conversations and collaborations [26].

VI. Research Fellows' Accounts of Mutual Benefit

Through our collaborative analysis, we organized benefits for URFs into four categories: (1) Professional development in social science research practices, (2) Personal transformation, (3) Academic development, and (4) External connections. In the category of external connections, URFs recognized being connected with other people differently than they were before – in terms of opportunities to: collaborate, communicate across perspectives, receive feedback from others, build interpersonal relationships, be financially compensated and build new forms of navigational capital.

VI.A. Professional Development in Social Science Research Practices

URFs consistently noted that the research collaboration provided opportunities for learning about the goals, methodologies, and collaborative practices of social science research. These benefits

include developing skill and proficiency with ethnographic methods, experiencing research activities as meaningfully connected — illustrating new ways of building knowledge, cultivating curiosity, developing communication skills, and seeing communication as integral to the development of ideas. We will talk about each of these aspects in turn and offer supporting evidence from our data sources.

URFs consistently acknowledged that they had developed new data collection skills around observing, noticing, writing jottings, and writing fieldnotes through our collaborations [19]. For example in the Sp21 exit surveys, one URF described learning to “think like an ethnographic researcher.” URFs noted that their research skills were honed and improved over time and use. For example in Sp21 exit survey data, URFs shared that their experiences helped them “get better at observing people and being able to notice key details” and learn the “process of taking field notes and interpreting them.” URFs noted that they had learned how to observe in different situations or settings, and how to analyze observational data. URFs not only recognized that they were becoming more skilled at these data collection processes, but also appreciated the power of observation, field notes, and synthesis. This development of skill and proficiency with ethnographic methods is well captured in one URF’s personal memo on benefits: “[*at every phase of the project*], I had a goal coming in; learning about the writing process, learning about the research process, and had growth coming out. . . . I was better at watching for and interpreting interactions between people... people watching is an insanely fun activity, and this fellowship not only gave me tools and a purpose to do it, but made me better at it. I grew in my skills and abilities, and became a better student and researcher because of it.”

Additionally, the URFs’ reflections illustrate their awareness of how various research tasks or activities are meaningfully connected, and as well as how these research practices serve particular purposes. For example in Fa21 exit survey data, a URF shared an appreciation for the weekly meetings, “one hour seemed like a good amount of time to get through a weekly agenda, go over takeaways from the previous week, and work on memos, reflections, and brainstorming [*interview*] questions for [*the postdoc*]. I also appreciated how the work in the study was meaningful, with memos being used later on, and the work on the paper in January.” Through URFs’ experiences observing STS educational spaces and synthesizing their observations, URFs became attuned to how subtle norms in a setting shape community practices and people’s experiences. For example in the Fa21 exit survey, a URF shared that, “As a college student, this research team has provided me access to a new perspective and a new experience in the field of ethnographic research. . . . Beginning with ethnographic methods such as jotting and over the course of our weekly observations and meetings, I have learned more about picking up on the subtle norms that influence the practices in a space and inform everyone’s experiences.” These quotations illustrate how URFs were not treated as merely informants collecting data, but were partnered with in making interpretations and arguments from the data [26].

URFs also valued the opportunity to engage with a variety of research methodologies that were strikingly different from their experiences working in science labs. For example in one URF’s personal memo on benefits, they shared that:

“[We learned] about the power of observation, field notes, and synthesis which was really interesting to learn about. From elementary school, we’re always told about

the scientific method - ask a question, make a hypothesis, set up an experiment, and write up a conclusion - but this was the first time in my life that we had moved away from that template into more of a humanities-based research approach. We truly learned how to observe different situations (which can be difficult over Zoom), communicate with others to get data, and reflect on our experiences in order to help create a paper.”

This quotation illustrates how URFs began to see their experiences observing, fieldnoting, and synthesizing as powerful. They became aware of how our processes for reflecting, communicating and writing with one another led to insights into the sorts of claims that were possible. Instead of only taking on a narrow and highly specialized set of responsibilities, the opportunity to experience a set of research practices as meaningfully connected allowed URFs to see this as an inquiry process, exposing them to more ways to build knowledge than just through a “scientific method” approach.

The URFs also described the research endeavor as cultivating greater curiosity in the study topic, modeling how macroethical perspectives develop within particular communities. For example in exit survey data from Sp21, a URF shared, “Overall, I'm really curious and interested about the topic of this study. We were presented with the background information during our first meeting and I was really intrigued by the data, especially as an engineering student myself. ...I'm really intrigued by this topic, and interested in the data and resulting analysis.” This quotation suggests that the driving questions and phenomena being investigated within this collaboration were engaging and intriguing to URFs which contributed to their interest development.

URFs described enjoying the forms of collaboration in this research team, valuing the communication skills they developed, and coming to see communication as integral to the development of ideas. URFs valued receiving useful feedback on their ethnographic writing which they saw as integral to building proficiency in academic research. URFs described building a stronger understanding of how to optimally perform research as part of a larger group in ways that lead to more efficient and more detailed work. URFs saw reflective discussions among the research team as helping to create and form a scholarly paper. For example in exit survey data from Sum21, a URF shared that, “The weekly virtual research meetings were especially helpful to me. I enjoyed discussing what we worked on that week and bouncing ideas off each other. It also allowed us to learn how to conduct research and analyze research. The discussions also allowed me to get a deeper understanding of the articles, my own opinions, others people's opinions, and the state of STEM education and ethics.” In this quotation, the URF is particularly articulate about how the process of bounc[ing] ideas off each other contributed to deeper understandings of articles, of other peoples’ perspectives, and of STEM education and ethics.

As URFs contributed to a particular phase of the project, they also began wondering about and puzzling over how the next phases of the project would look, how various research activities would be connected together, and what role they may continue to play in the ongoing work. This speaks to URFs sense of “prospectiveness” from Ford [31]. For example the URFs shared:

- “How [*will*] the information collected be compiled and analyzed?”
- “What literature should we start reading? What exactly is this field that studies

underlying learning patterns called?”

- “I am wondering what the next steps for this research project are and what future URFs will do.”
- “How the paper will be written overall and just about the whole process of it.”
- “What is the overall goal of having URFs to help you in the study?”

We appreciate that these “wonderings” highlight: (a) some facets of the work that were opaque to URFs at particular points in time, (b) URFs’ anticipatory engagement with what comes next in the research process, and (c) power differentials that remained on the team. For example, these comments from URFs illustrate that the research leads maintained significant decision-making authority over the form of future collaborations, which we will return to in the conclusion.

VI.B. Personal Transformation

URFs across multiple project phases reported significant personal benefit to participation in the research team. One of the most commonly reported benefits was becoming more introspective and observant. In one of the Fa21 exit surveys, one URF wrote, “My participation in the [*course number*] data team shaped my experience as a college student by teaching [me] to think more deeply about the things around me,” and others wrote, “I am more aware now. I subconsciously compare other class environments to the class that I observed, see what's different and similar. I notice things more, such as how people in classes are reacting” and “being a RF has helped me realize how incredibly interconnected everything is and how every issue has intersectionality.” Based on these and other responses, it is clear that many URFs felt that the research team opportunity was enlightening and promoted introspection, reflection, and emotional benefit.

Another commonly reported benefit by URFs was increased awareness and understanding of macroethics and the politics of service-learning, one example of this being a URF who wrote in Fa21, “I have learned a lot about how the perspective of stakeholders should be the primary influence for interventions, not the agenda of the person trying to ‘help,’” and “Observing the course has allowed me to speak to and learn from people that I otherwise would never had interacted with...I learned a lot about the inner workings of those communities and how race, gender, and disability affect them.” The opportunity to work on the research team clearly shaped URFs engagement with and understanding of macroethical issues, in this case racial and gender disparities, as well as ableism.

Some URFs, in fact, mentioned that their participation in the research team and their subsequent personal evolution as a result led to concrete change in their lives. One URF wrote about choosing to decline a volunteer opportunity after feeling that it would be detrimental rather than beneficial to the community, citing URF discussions regarding critiques of “engineering to help” programs and narratives [46]. Another URF wrote about discovering through the URF position that they were not as interested in quantitative research as they originally thought, leading them to switch universities in order to pursue their new goal of public health policy.

VI.C. Academic Development

The research fellowship served as a significant contributor to many URFs’ academic development. Many URFs agreed that their role had allowed them to take up different

perspectives on the STS program and their academic life. For example, one URF mentioned, “My participation in the [course number] data team shaped my experience as a college student by teaching [me] to think more deeply about the things around me. Field note-taking interpretations made me ask questions and think more critically about even the most common things taking place in an environment. My participation in the [course number] data team shaped my experience as a college student because it made me appreciate my experiences more. I loved talking about the class and found more interest in the class itself when I reflected on it.” Here we see the URF describing greater degrees of engagement and interest in the STS courses through their role as observers.

Most URFs appreciated that the URF experience allowed them to know more about the STS program and connect their STS experiences to other facets of their lives. For example, one URF shared that although they liked many aspects of the STS program before the research fellowship, they “had a hard time understanding why the curriculum is the way it is.” They added, “The more I observed and reflected on the STS courses, the more I understood some of the class dynamics and values.” Another URF in the Fall 2021 survey data mentioned, “My participation in both research teams helped me dig deeper into topics of culture, diversity, and inclusion whenever raised in class activities. More specifically, in the [course number] data team, when diversity and inclusion were discussed in class, a lot of connections were made to power dynamics and how these things are present at UMD for students and staff.” In this quotation we see a URF describing how through the fellowship, they developed a more attuned lens for noticing the ways power dynamics shaped their college experiences.

In addition, some URFs came to see macroethics and STS ideas as relevant to their academic STEM domains. We see evidence of the research collaboration shaping URFs academic pursuits in the following quotations from some URF responses to Fa21 exit survey:

“I was able to apply some of the research in a final project for my public health class as we were challenged to address a health issue in a community. We chose the STEM community at UMD and we focused on mental health. One of the aspects we focused on was professor-student relationships and how they impact mental health and I was able to add perspectives from STS into that.”

“This research team has expanded my understanding of the STS program, as I have seen how STS and ethical education in STEM are an expanding field, and provide many forms of growth that all students should experience. Prior to my participation, I had simply thought of the STS program as closed to our own experiences, and a space for thoughtful and critical thinking about science and technology. I had not given much thought to the purpose of the STS program, and how it tries to shape students to evaluate situations ethically and be cognizant of social, political, and economic dimensions present in our day to day lives.”

In the first quotation, we see evidence of a URF extending STS ideas made more visible from our research into another course project – for example, critically examining instructor-student interactions in STEM and the impacts of those interactions on students’ mental health. In the second quotation, we see evidence of a URF seeing the importance and growing need for ethics

education in STEM. This URF describes STS stances as not merely tied to matters of personal preference, but as striving to shape how students evaluate situations ethically in ways that acknowledge and explicitly model the “social, political, and economic dimensions present in our day to day lives.” URFs’ experiences within this research collaboration seems to have sparked their interest in the field of macroethics in STEM as well as cultivated some important macroethical reasoning skills and ideas that URFs see as relevant to STEM domains.

VI.D. External Connections

The category of “external connections” captures an assortment of ways that URFs recognized being connected with or supported by other people differently than they were before – in terms of opportunities to: collaborate, communicate across perspectives, receive feedback from others, build interpersonal relationships, be financially compensated for their work, and develop new forms of navigational capital.

Many URFs reported that their work as URFs provided valuable opportunities to collaborate, communicate and reflect on their experiences in the STS program and society across different perspectives. URFs valued “having a team with different background experiences,” as one URF wrote in their Spr21 exit survey responses. The combination of individual reflection and collaboration allowed for an exchange of diverse ideas, while also giving URFs the “freedom to work on [their] own and come to [their] own conclusions.” Another URF addressed a similar theme in their writing,

“Consequently, I also appreciated how, for the most part, every week’s tasks culminated in a group meeting. It’s a discussion—I don’t have thoughts on every topic and I don’t have to pretend like I do. But when I do, my contribution is valued and taken under consideration. The research leads had us thinking a certain way, they had questions that needed answering as well as their own curiosities, but the majority of the analysis was open ended. We were, a lot of the time, allowed to pursue almost anything in the space, which I think provides for not only a better experience as a student researcher, but more interesting and insightful observations for the research project. Letting people focus on what they are already going to focus on leads to deeper analyses.”

In their Fa21 survey responses, one URF described, “I valued how everyone is given an opportunity to share and no one is judged for anything. I also like how we discuss things in depth, rather than only focusing on writing. It was nice to work together to come up with claims and provide feedback to each other.” One URF reflected on the process of collaboration in a memo, where they wrote, “I’ve had two other professional “research” roles ... The biggest difference I felt in the day-to-day work was the overt level of collaboration between all the participants, a welcome change of pace compared to the relative solitude of my last few experiences. We brainstormed, we discussed, we wrote, and we read, and then we did it all again as a group.” Throughout the weekly meetings and individual reflections, URFs developed their own perspectives on and interpretations of events and then through dialogue and exchange were invited to revise or reconsider their interpretations from other points of view. URFs came to see this form of collaboration as an asset for them in navigating their professional worlds.

Several URFs reported cultivating new relationships through their participation as URFs - with other STS students, with STS instructors, with their URF peers, and with their research mentors. One URF wrote “The freshman STS colloquium was online, hardly a great place to get to know others. I’ve gotten to know fellow student researchers and gotten to know people through my observations.” In their Fa21 survey responses, one URF said, “The smaller research team allowed for me to build better relationships with URFs in my team and with [*one of the research leads*].” In the same set of survey responses, another URF said, “I value the ice breakers, I believe this allows me to get to know some of the other fellows on a more personal level. This also allowed me to be closer to the fellow I observed with which then led to understanding of each other's flow of writing.” In this way the URF is describing how the level of intimacy and trust between researchers impacted their ways of observing together and understanding each others’ writing.

One URF saw these collaborative relationships as enjoyable and critical to their learning. For example, they wrote, “The weekly virtual research meetings were especially helpful to me. I enjoyed discussing what we worked on that week and bouncing ideas off each other. It also allowed us to learn how to conduct research and analyze research. The discussions also allowed me to get a deeper understanding of the articles, my own opinions, others people's opinions, and the state of STEM education and ethics.”

The URFs also consistently valued: (a) having a flexible and meaningful work opportunity with clear expectations, (b) being compensated for their time and work, (c) developing a track-record of work experience for their resumes, and (d) building relationships with professionals that could write recommendation letters for them in the future. For example, one URF mentioned that, “This research collaboration was my first working opportunity, which has been a great way to gain experience with research during my education. As a student currently pursuing medical school, having a variety of experience from different fields is very beneficial. Including the research fellowship on my resume would show my willingness to be open to pursuing a career in the research field.” Speaking to this theme of resume-building from another direction, a different URF mentioned that, “ [*This research position*] shows dedication and helps my brand as an ethical engineer. Employers don’t tend to tell you whether specific things contributed to their decision, but I enjoy having it on there, as a nice separator from the people who are coming in with primarily technical experiences.” Another URF valued having a paid position that aligned “with my professional interests and goals.” Students acknowledged how these facets of their working relationships with the research mentors impacted their experiences within the role and their future navigational capital within the labor market and potential applications to further their academic pursuits. Importantly, one URF acknowledged that cultivating relationships with the research leads was complementary to developing these other forms of navigational capital, “...I was introduced to two incredible researchers. There’s the outwardly visible aspect of this, seen in recommendation letters and references at a time when I desperately needed it after a year of online school and distant teachers... But it was more than that, it was an introduction to people who make this their job, and in all honesty, two of the nicest and most inclusive faculty members I’ve met at this school. Isn’t that itself a benefit?”

VII. Descriptions of joint work processes that enabled mutual benefits

In this section, we elaborate on the joint work processes that our co-authoring team saw as consequential for the forms of mutual benefit that arose in our research collaboration. We group these work processes into six areas: (1) Clear expectations and shared documentation practices, (2) Writing practices for developing ideas and iterating on ideas within a community of scholars (3) Affordances of the observing role, (4) Reliance on multiple modes of expression, (5) Meaningful exchange of ideas in meeting discussions, and (6) Continuities between the STS program and the research collaboration.

VII.A. Clear expectations and shared documentation practices

The project research leads and mentors drew on past experiences co-working with undergraduate and graduate student leaders in other contexts to structure the design of our research collaboration. In particular, they drew on Turpen's past experiences developing collaborative relationships with students within the Access Network [39-41]. The research leads, Turpen and Radoff, adapted some of Access Network's organizational structures around shared documentation and brought these structures into our research collaboration with STS students. Our shared documentation practices are exemplified in four areas: (1) Creating clear and transparent job descriptions for URF positions, (2) Using an organized and predictable meeting notes format, (3) Using a shared digital Google Shared Drive space, and (4) Being flexible with one another.

Research leads were deliberate in creating clear and transparent job descriptions for each URF position. In these job descriptions, prospective URFs could find bulleted lists of the types of tasks they would be doing and see expectations and timelines explicitly delineated. These job descriptions clearly articulated the start date and end date, the time commitment involved, and compensation. They also worked to communicate what URFs could reasonably expect from the mentors as well. The first term in Sp21 was deliberately short (about 7 weeks), so students could try out the role and see if the work was a good fit for them. URFs could then apply to continue with us for full-length terms in Su21 and Fa21 (about 13 weeks). As the nature of the project work evolved, the expectations in the job descriptions would also evolve. URFs currently in these roles often helped revise the expectations and tasks based on how the collaboration went that term, the progress we had made as a team, and the forward-looking needs that we identified. These job descriptions also included an explicit accessibility commitment (adapted from the Access Network) [39-41].

Research leads intentionally introduced and regularly used an organized and predictable meeting notes format (adapted from the Access Network). We structured our meeting notes document as one continuous Google Doc with meeting information (e.g., meeting times and Zoom link) and a table of contents at the top, key document links listed next, and clear headings for each meeting. This shared meeting notes document was always prepopulated with a detailed agenda co-constructed by the research mentors and presented in table format. The table format included a column for brief activity titles and rough time allotments, a column for more detailed activity descriptions and prompts in the middle column (to which notes would be added), and a column for decisions or action times. Detailed notes were taken during the weekly meetings to capture the thinking of the group as we discussed and were embedded in a row with the corresponding agenda item. During weekly meetings, the research mentors primarily took up the note-taking

roles to allow URFs to focus more on idea generation and reacting and responding to one another's ideas. The final row of the table for each meeting clearly articulated tasks or "next steps" for research team members.

We also maintained a shared digital space for sharing files (e.g. meeting notes, field notes, written reflections, memos, research articles, etc.) and enabling collaborative editing / commenting on each others' writing. We recognized that this sharing of work-in-progress writing and initial ideas would require a certain amount of vulnerability among URFs. We will talk more about how shared access to these files serve particular purposes as we walk through our writing routines (in section VII.B) and our ways of talking to each other (in section VII.E). As one URF put it, they appreciated "having an organized shared Google Drive with everyone."

Many URFs appreciated this organizational structure and the detailed notes, which allowed URFs that may need to miss a meeting to bring themselves up to speed with where the group was at. For example, one URF mentioned, "The meeting notes were extremely helpful in that I always knew where to go if I needed anything. They were always organized and had everything that happened, will happen, and needed to happen. The google drive was also very useful and organized." Another URF was very specific in expressing their appreciation for the meeting notes format, "I really liked the use and layout of the meeting notes as it guided the meetings, and was available as a reference during the week. I also appreciated that the links to an article, folder, or document were included in the meeting notes." Another URF said in the Fa21 exit survey, "I have valued the structure of the meetings and data team notes, as having a clear plan every week of what needed to be done, and what would be worked on in the future."

Some URFs appreciated the balance of asynchronous and synchronous collaboration, and the grace and flexibility that research team members gave one another. For example, one URF mentioned that the "deadlines and schedules were largely open and flexible" which worked well for them. As one URF put it, "During the semester, I was under a lot of pressure academically and personally, so I tried my best to manage my time. When that was not possible, the research team leads were very understanding and flexible with me taking more time to upload the data." Another URF mentioned that they "really appreciate how the weekly meetings are held virtually, because it's tough for me as a daily commuter to attend in-person meetings." These reflections on our research collaborations have served to make us more aware of how the demands of in-person meetings may serve to exclude some students' participation.

VII.B. Writing practices for developing ideas and iterating on ideas within a community of scholars

Our joint work relied on a few types of written artifacts and writing practices, which URFs described as helpful for gathering one's thoughts and reflecting ahead of synchronous meetings. The first was ethnographic field notes, collected in STS courses by URFs who were not enrolled in the course. The second was a reflection, written after each class by enrolled URFs. The third was reflective and analytical memos. The fourth was collaborative annotations on assigned readings. We describe the work processes and practices for each of these below.

VII.B.1. Ethnographic Field Notes

In the Spring of 2021, the research leads introduced URFs to ethnographic field noting. URFs read the first three chapters from Emerson et al. (2011)'s, *Writing Ethnographic Fieldnotes* [19], focused on the role and mechanics of collecting fieldnotes in ethnographic research. URFs also watched short videos from the ethnographic project, "A Cluttered Life: Middle-class Abundance" [47, 48] to see an example of what results of an ethnographic study might look like. Before URFs got started collecting field notes in course contexts, they were tasked with gathering field notes of a typical "meal time," to give them a flavor of what it was like to jot field notes while observing in a social setting. We developed work processes for collecting initial jottings while conducting observations in the course and for protecting time to revise jottings after the fact. The research leads developed a "field note template," to provide some structural and substantive support for field noting. The template had three sections: (1) Brief Background on the Setting, (2) Descriptive Accounts of Classroom Events and Social Interactions, and (3) Interpretations of Classroom Events and Social Interactions (adapted from instructional resources from Dr. Noah Finkelstein and Dr. Ben Kirshner). Within each section there were more detailed descriptions of kinds of things to focus attention on. In the "interpretations" section, URFs were guided to consider three dimensions: How STS practices are performed and legitimized in the space, what are the social practices and norms that point to what it means to be a "good" participant, and instances of power, conflict, celebration, and authority.

Field notes were written in google docs, so that the notes could be easily shared and collaboratively annotated. URFs tended to collect individual field notes, but sometimes URFs observing together would collect jointly produced field notes. In Fa21, data teams began a practice of regularly annotating and commenting on each other's field notes, a sociotechnical innovation we call "multivocal" field noting. In-line annotations were made in different colors, to mark the different authors, and comment bubbles were used to add interpretive commentary or ask clarifying questions about what was written. These multivocal field notes would go through multiple rounds of revision, with research leads and URFs who were enrolled or observing alternate days adding additional information and clarifying details, or alerting the field note taker to when their notes might not make sense to an outsider. At the start of Fa21, when our team was learning how to generate multivocal field notes, we spent time during meetings (synchronously) collaboratively annotating a particular field note, developing a set of shared practices for multivocal annotations, and debriefing what the process was like. One URF said of this process in the Fa21 exit survey, "It was also great to spend time in the meetings commenting and discussing field notes together, especially early on, as it allowed us to integrate the perspectives of the entire team, creating more effective field notes. Similarly, the commenting and 'pinging' provided helpful reminders of what to expand and add to our notes." By 'pinging,' we suspect the URF is referencing our strategies for tagging one another within the comments function which would send an email notification to a collaborator with the associated document linked.

VII.B.2. Written Reflections

During the Spring of 2021, written reflections by enrolled RFs were minimally scaffolded, merely prompting URFs to reflect on what had happened in class that day. These accounts were meant to be more subjective than the field notes, so the research leads wanted to leave the structure open to enable URFs to share unencumbered by a constrained set of prompts. However,

not many URFs submitted the reflections and after receiving feedback from RFs at the end of the semester, Dr. Radoff and Dr. Turpen decided to create a “reflection template” loosely modeled after the “field note template.” This template prompted a series of more targeted reflections: (1) How are things that are happening in the world or in your communities shaping how you show up in STS spaces this week? (2) What are a few moments that stood out to you in class today, and why? How did you feel in those moments? Or what did you experience in those moments? (3) Please reflect on the ways instructors and your peers are sending messages about what’s valuable to be doing in STS spaces, (4) In what ways did particular STS Thinker Skills provide insights for you today? and (5) What are your evolving thoughts on the sorts of professional work you might want to do or not want to do? And why? (an “optional” question, which URFs rarely answered).

After introducing this template in Fa21, the URFs submitted reflections much more regularly and provided ongoing feedback that helped the research leads refine both the reflection and field note templates. Regarding the templates, one URF reported that, “Field notes and reflections each had guiding prompts which helped to guide my attention on what I should be paying more attention to, or less attention to and helped my observations to feel more organized and relevant.”

While these reflections were not “multivocal” in the same way that the field notes were (since we wanted to preserve the subjective voice of the author), URFs and research leads would occasionally add comments, and excerpts from the reflections would often get layered into the field notes when they were relevant for understanding certain events or actions.

VII.B.3. Reflective and Analytical Memos

URFs produced a variety of reflective and analytical memos, primarily during Su21, when our work was focused more directly on data analyses, and in Fa21, when we began to build claims about higher-order patterns observed over the course of the semester. These memos supported URFs’ engagement in different kinds of “knowledge-building” games, like using particular analytical methods to analyze data, connecting analyses to “big ideas” or constructs in the literature, and articulating personal and political values as they relate to the research. The research leads provided different forms of scaffolding depending on the goals of the memo, sometimes in the form of guiding prompts, and sometimes facilitating synchronous discussions during the team meetings. Like with the multivocal field notes, we developed a practice of reading and commenting on each other’s memos, and revising them based on the feedback we received.

VII.B.4. Collaborative Annotations on Assigned Readings

During the Summer of 2021, URFs read foundational pieces of engineering education and STS literature that were relevant to our joint analytical and reflective work. URFs were typically tasked with reading one article per week, and they would asynchronously contribute notes and insights about the article to a shared google doc in preparation for the next meeting. In this document, each URF contributed (1) a summary of the article’s key points, (2) points of confusion or clarification, and (3) discussion prompts. These annotations provided opportunities

for offline collaboration and engagement with one another's ideas. They also helped the research leads structure the next meeting agenda.

VII.C. Affordances of the observing role

Many URFs appreciated the affordances of the observer role within college classes. For example, one URF mentioned in a Fa21 exit survey, "Field note-taking interpretations made me ask questions and think more critically about even the most common things taking place in an environment." URFs valued putting focused attention on making sense of the social organization of the setting and reflecting on why it may have been intentionally designed in specific ways.

When URFs were observing STS courses, they were able to partially step out of the typical positionality of the student. As one RF put this, "The RF role, however, gave me the opportunity to observe professors without a stake in the situation. It allowed me to truly judge how professors made decisions for their curriculum, how they interacted with students, and how they impacted their students." In this way, the observing role seems to relieve the pressure to perform in the classroom, and allows the URF to critically assess a college experience for the learning opportunities it provided.

URFs' role as an observer in the space at times disrupted some of the power dynamics that can commonly exist between instructors and their students, offering URFs a new vantage from which to consider a course and its design. For example, one URF described:

"The benefit of being in the RF role as a current college student was that I got to compare these STS professors to other professors around the university. I saw a stark difference in the way [*STS Program Instructors*], and other humanities-centered professors interacted with students versus my calculus professor, my chemistry professor, and other STEM-oriented professors interacted with students. This role allowed me to pull back and develop a sense of the 'sociological imagination' to rid my student bias and truly judge how my professors taught and treated their students. It also allowed me to more easily interact with professors because I was given the opportunity to see and interact with professors outside of the classroom. It boosted my confidence in my communication skills and has genuinely benefited me..."

This quotation illustrates the URFs' growing awareness of meaningful pedagogical differences in humanities courses and STS courses as compared to other STEM courses. This URF described the observing role as growing their confidence in interacting with instructors. In this way, the research fellowship shifted their academic relationships and the perspectives they were able to bring to building interpretations of these college courses.

VII.D. Reliance on multiple modes of expression

One aspect of the research work processes that many of us appreciated was how we had multiple modes of expression. Field notes and written reflections were very open-ended, allowing URFs to share observations in a way that was most comfortable for them. Despite having written forms

of data, many team members had doubts about their interpretations which could then be shared and considered within the team. The weekly data team meetings provided them with an opportunity to engage in such discussions. The research team was given several opportunities to give and receive feedback in many forms, whether it be through suggesting or commenting on the documents, discussing as a group, or one-on-one feedback from the research leads.

The field notes and reflections are forms of data, but they also acted as a way for URFs to share their own experiences and personal perspectives on the things they related to or observed. Templates with guiding questions were provided for both field notes and reflections, but did not overly restrict URFs. Each URF had their own way of writing that contributed to better understanding of the observed class and the different styles of writing were always encouraged by the research team leads. Personally, this motivated one URF to write more comfortably in their own style. A URF once shared with the team that he tends to include some of his opinions into field notes out of habit, but that's actually helpful for the rest of the team to contribute their perspectives in order to gain a better understanding of what happened.

The most difficult part about data collection is making interpretations. Team members often had clarifying questions or additional thoughts that they had not mentioned in the documents. During weekly virtual meetings, everyone was given an opportunity to develop some interpretations and identify patterns within all the observations as a group. It was also a chance to ask questions so that everyone had the same understanding. In every meeting, the research team leads encouraged URFs to initiate these conversations for the benefit of the team and themselves. The virtual meetings encourage URFs to express themselves verbally if they are not as comfortable capturing their thoughts in writing.

Throughout the research, there were moments of doubt or confusion when documenting data regarding things like what needs to be included, or whether the information was accurate or understood correctly. While everyone was encouraged to contribute in whatever way they preferred, there were multiple avenues for giving and receiving feedback within the team—verbally, through suggestions or comments on documents, group discussion, or one-on-one feedback from URFs or research leads. Feedback seemed to help URFs in improving their writing but also in making collective sense of the data they collected.

VII.E. Meaningful exchange of ideas in meeting discussions

During the academic year, research team meetings were a once-weekly event. At the beginning of the school year, Dr. Turpen and/or Dr. Radoff reached out to each research fellow to determine their availability. Combining the received schedules, the research mentors determined constructed data teams accommodating URFs schedules with attention to balancing teams with some observers and some enrolled student perspectives. The decision to hold the meetings virtually was made for convenience purposes, as a pandemic precaution, and out of necessity, given that at least one of the research mentors was living in a different state.

Despite the lack of in-person communication, the weekly synchronous meetings were productive, suggesting that video calls are a viable option for this type of work. One URF described appreciating the “frequent and fast communication with everyone.” Meetings followed

a more or less standardized schedule. The first five or so minutes of the meeting would be dedicated to an icebreaker, which served to open up channels of communication within the group, both for academic purposes and extracurricular (i.e. establishing social connections between URFs). As one URF put it, “They [*the research team leads*] also frequently checked in with me and offered support at any time. This not only helped me as a research fellow but led to personal connection as well. It is not often that you gain anything more than a professional connection in a research field, so having that sense of dependability and community was a big plus.”

Next, the research group would either move on to discussing relevant logistics (i.e. “housekeeping”), or directly to the main focus of the day’s meeting. During the academic year, this would usually entail reading through one or more of the reflections or field notes written by URFs and giving clarification for certain events which were mentioned, or having an open discussion regarding certain claims or observations the writer had mentioned. During the first meeting of the data team, one of the research leads and the URFs drafted a set of ground rules or norms which were to be observed throughout the entirety of each meeting. These rules included standard items like “No interrupting”, but also included less standard items, like “Respect other team members’ life experiences.” It must be asserted that these rules were partially drafted by the research mentors, with additions and amendments being made by URFs. This largely reflected the roles of each group member, with the research mentor loosely facilitating group discussions but not forcing it to go in any particular direction. While this may not have worked well with a different (less tolerant, perhaps) group, the fact that URFs had been selected for their diverse life experiences and openness to new ideas and experiences meant that the dynamic was smooth. One URF mentioned that the meetings ran smoothly and that they “also appreciated that times were allocated to questions during these meetings - it was very helpful.”

Conversations surrounding other URFs’ writing were not very structured, though they often revolved around classroom dynamics, including dynamics between the STS professors and their students. Certain discussion topics inspired by the URFs’ field notes were listed on the meeting notes agenda, and others spontaneously came up in conversation between URFs. URFs were encouraged to speak up (respectfully and not interrupting one another) whenever an idea occurred to them. URFs were not restricted to specific topics, and rarely did a facilitator tell a URF to switch topics. Often, things said by one URF would be used as a springboard for a comment made by a different URF, and in the cases where conversation died down or a URF said something which stood out, the group’s facilitator (one or both of the research leads) would circle back to a point made by a URF earlier to further discussion.

Throughout the entirety of the meeting, detailed notes would be kept regarding what the URFs and facilitators said. These notes were paraphrased, as it would not be feasible for the facilitator to directly transcribe the words of each speaker. It is important to note that the majority of the note taking was performed by the facilitator(s), though at times URFs would add additional details to the meeting notes. Similarly, the drafted agenda for each meeting was primarily prepared by the facilitator(s), who reviewed URFs’ most recent field notes and reflections before each meeting, though at times during the meeting the URFs would diverge from the agenda and instead discuss topics which they deemed to be more important (e.g., unexpected events which had occurred in the class that day). Usually, the facilitator would put items in the agenda that

related to one or more of the URFs' written artifacts, and URFs were expected to have read each other's field notes and reflections, at the very least familiarizing them with what topics may be discussed during the meeting.

Research team meetings did not use any formal organization method for talking in turns (e.g. a "talking stick") as URFs were able to respectfully listen rather than speaking over one another. Conversation remained purposeful, with few lulls. In fact, it was somewhat common for the group to cut off certain conversations to ensure that there was time for each agenda item. Despite this, some agenda items were skipped due to a lack of time, and either discussed at the next meeting, or discarded altogether. For most conversations, the facilitator was able to bring up the topic of conversation and URFs would begin discussing it immediately, "piggybacking" off of each other's ideas.

VII.F. Continuities between the STS program and the research collaboration

As mentioned earlier in the paper, this research project focused on studying the cultural practices of the UMD STS program and how these practices support students' macroethical reasoning. The STS program, through its directors, instructors, and other partners, embodies certain values, goals, practices, and knowledge bases that laid the foundation for the work we wanted to accomplish together in the research fellowship. Because the research leads didn't have to initially seed particular ideas with the URFs, we were able to accomplish a lot more together than we would if we had needed to spend time establishing the legitimacy of qualitative research methods, building up a shared knowledge base, or developing lenses for seeing how power functions in systems. We will talk in turn about cultural practices and knowledge bases from the STS program that we were able to build from in our research collaboration including: systems thinking tools, ethnographic methods, culture of collaboration, and ethics of care.

VII.F.1. Systems thinking skills and touchstone ideas

Tomblin and Mogul (2020) outline seven systems thinking skills that are referred to in the program colloquially as the "STS thinker skills": Looking for ethics in artifacts, listening contextually, making meaning, seeking stories about science and technology's past present and future, locating power in systems, asking STS questions, and hosting STS parties. The program is built to support critique of ideologies such as meritocracy and capitalism, and students practice seeing the harms these ideologies incur on people. These skills are explicitly introduced to students in their first semester colloquium course, and opportunities to engage in these skills are woven throughout the STS program coursework.

URFs came to the fellowship with a foundation of participating in these practices and skills and with knowledge that these skills can provide insight into how systems function and what macroethical issues arise. For example, in the summer session of the fellowship, when URFs were tasked with analyzing focus group interviews, we asked them to produce memos examining transcripts with multiple lenses (e.g. personal, political, analytical). They drew on these systems thinking skills to examine power dynamics, positionality and relationality of various actors in the design scenario.

VII.F.2. Use of ethnographic methods

STS students are encouraged to use STS thinker skills in course activities, for example, in mapping exercises where students “create maps centered on a broad topic (e.g., light pollution, developing vaccines, medical supply distribution, COVID-19 safety protocols) that identify relationships among artifacts, stakeholders, and social activities as a way of generating STS questions (Neely, 2011)” (Tomblin & Mogul, 2020, p. 6). Many of these activities rely on ethnographic observations, where students collect data to understand how a sociotechnical phenomenon plays out in a particular setting. Thus, URFs came into the fellowship already having some exposure to ethnographic methods, and having seen how these methods become valuable tools for inquiry. Instructors also used the URFs’ presence as a marker for students in the course of how valuable ethnographic methods are for making observations and how continuous these methods are with other kinds of epistemic endeavors.

VII.F.3. Culture of collaboration and community

A central feature of the STS Living Learning Program is the development of community and cultivating a culture of collaboration. This commitment marks a departure from modes of engagement common in other disciplinary (especially STEM) spaces students experience. STS courses are often organized around discussions (in both small and large groups) and instructors place a strong emphasis on collaboration, both inside and outside of class. Most classes began with an ice-breaker or “stoke” which got students into a participatory mode, seeded important ideas to come in the class and supported relationship building. Through these experiences, students were supported in practicing discursive skills, like how to respectfully disagree, how to have difficult/contentious conversations, and how to build on each others’ ideas. They also emphasized the value of seeing multiple perspectives.

These experiences laid the foundation for URFs to approach the weekly URF discussion-based meetings with a sense of openness and trust that their ideas would be valued and heard, and with skills for fostering collaborative discourse. They also came with a general appreciation for the types of generative outcomes that this kind of collaborative environment could support.

VII.F.4. Ethics of care

The STS instructors see and value students as multifaceted humans who have busy and complicated lives. They practiced ethics of care, communicating to students that their wellbeing is more important than work production, especially during the Covid-19 pandemic. Not only did instructors explicitly express these values, but their actions were in alignment with them: they made space during class time for students to go outdoors and unwind, they exhibited flexibility in their grading and attendance policies, and they consistently checked in with students and made space for them to express their feelings and emotions.

The research leads worked to mirror the values and ethics of care of the STS instructors, similarly communicating that URFs’ wellbeing is of utmost importance, and making available multiple avenues of participation (e.g., recording meetings and taking careful meeting notes,

creating alternative “assignments”) so that students could miss meetings and miss deadlines without worrying that it would have negative consequences to themselves or to the project work. The project leads also attempted to build in redundancies for example, by putting URFs in multi-people teams, so that others could easily step in if someone needed to step back, or to fill their peers in if they needed to take an absence.

VIII. Discussion

In describing our joint work processes, we captured some of our team’s sociotechnical innovations through descriptions of the activities, routines, and artifacts that structured our work *and* the purposes these activities served. Some innovations were constructed by the research mentors in order to: (a) support collaboration and mutual engagement, (b) support engineering students in developing competence with ethnographic methods, (c) expand awareness of the engineering education research literature, (d) empower students to refine their own thinking about macroethics and the purpose of education, (e) recognize particular “knowledge-building” games within research activities, and (f) create space for students’ values and political agendas to shape the direction of the research. Other sociotechnical innovations that were iteratively refined in dialogue with URFs and through the process of coworking with URFs, such as GroupMe communication channels, multi-vocal field noting, and prompts for scaffolding reflections on classroom events.

In modeling the social organization of our research collaboration, we worked to illustrate how our joint work processes weave together and often support one another. As such, these joint work processes are not distinct but mutually reinforcing: (1) Clear expectations and shared documentation practices, (2) Writing practices for developing ideas and iterating on ideas within a community of scholars (3) Affordances of the observing role, (4) Reliance on multiple modes of expression, (5) Meaningful exchange of ideas in meeting discussions, and (6) Continuities between the STS program and the research collaboration. Our team recognized these joint work processes as consequential for the outcomes our team experienced: (1) Professional development in social science research practices, (2) Personal transformation, (3) Academic development, and (4) Building external connections.

Our findings suggest that it is not enough for research mentors to care about research mentees, but that care must inform how one designs and enacts research collaborations. Some of these seemingly mundane work processes (compensating URFs, well-organized notes and clear/transparent expectations) might not immediately come to mind when centering ethics of care, but they can help support ethics of care. Our analysis illustrates how the deliberate social and technical organization of this collaboration (with an attention to human rights and capabilities) enabled particular forms of mutually beneficial outcomes and relationships.

In many research contexts, research mentors may tend to take on a single undergraduate student and assign them to work relatively independently on a small project. The design of this research collaboration stands in marked contrast to this model. This paper illustrates that students can come to see their peers as resources in doing research, and deeply appreciate having space to engage with one another and the different perspectives that people bring to making sense of cultural contexts. Many URFs recognized the power of our “data team” structure where

observing URFs and enrolled students collaborated to collect, analyze and interpret data, each taking on complementary responsibilities in the process. URFs were able to recognize the powerful meaning-making that was supported by reasoning together across these roles. Through these collaborations and artifacts like multi-vocal field notes, we were able to build more robust interpretations and claims collaboratively across multiple perspectives.

Building on participatory action research traditions, the research leads also attempted to provide a research experience that was (1) *situated and inquiry based*, by embedding URFs in STS courses, developing a toolkit for “seeing” power and culture in STS spaces, and engaging URFs in critical inquiry into events and interactional dynamics within those spaces, (2) *participatory*, by making space for URFs to follow their own interests and political agendas, modeling how to bring oneself and one’s commitments to the research in substantive ways, and providing lots of on-ramps for URFs to participate in a variety of ways, and (3) *transformative and activist*, by creating opportunities for URFs to relate the research work back to their lives and the STS program and encouraging URFs to identify injustices in their lives that we can work to change.

As research leads, we value what students bring to the research work. We worked to seed some ideas and offer some tools, but not overly constraining what they notice. Students’ rich meaning making across settings allow for students to develop strong visions for how education could be organized differently. For example, the RFs described seeing the ethics “modules” that were inserted in the Introduction to Engineering Design course being minimized or dismissed by their peers in “mainstream” engineering spaces. They developed strong agendas such as wanting to see STS thinking permeate the engineering college as a whole, and not being satisfied with this being an “optional” add-on experience for only a subset of engineers.

Looking back, we are proud that we prioritized spending our time together during a pandemic. It was a lot to take on together during these stressful times, but it was also very rewarding. These partnerships were enabled by creating opportunities for URFs to take up leadership roles and trusting one another with those roles. As research mentors, we are excited by the URFs sustained and continued interest in contributing to this research project, and see this as additional evidence of the strength of the collaboration we have built. We look forward to continuing to build important research findings together, and to see how each of us carries these learnings forward with them into future activities.

IX. Conclusion

Through this analysis of our research collaboration, we intend for our readers to see the value of engaging in deliberate human-centered design work in the context of structuring research team collaborations. Engaging in human-centered design work necessitates acknowledging some power that project leads have in the design of the social organization of the project work and collaborative work processes. Some of this power in establishing, negotiating and refining work processes can be distributed or shared with research team members. Through our reflections on our approach to designing this research collaboration, we recognize research collaborations as complex sociotechnical systems. This recognition creates opportunities for project leaders to acknowledge research team members as human beings (e.g. team members’ human rights and expanding human capabilities) and to resist focusing solely on efficient work production.

In future work, we would like to analyze the power dynamics present within our research collaboration. For example, if we analyze our research collaboration through the lens of “locating power in systems” (Tomblin & Mogul, 2020), we can recognize facets of our work where the research leads maintained substantial control and power over particular decision-making processes within the project. This included deciding URF compensation, the start dates and end dates of URF terms, and URFs’ scope of responsibilities. There were also some project management and budget management processes where the research leads did not orient to students as partners. In the future, we are interested in better understanding how these distributions of power may enable (or constrain) collective responsibility over the project and URFs’ proudness over the project work [49].

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