ABSTRACT

Title of Dissertation: A STUDY OF HOW INEQUITIES EMERGE IN INTERACTION IN UNDERGRADUATE PHYSICS AND ENGINEERING EDUCATION SPACES

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My research uses interaction analysis to investigate two STEM education spaces and discuss how instructors can and should notice and address unproductive group dynamics, particularly in the service of creating more humane learning environments. The primary goal of this work is to investigate how inequities emerge and continue as interactions in STEM spaces unfold. In the first chapter, I describe how my own experiences of marginalization in physics classrooms and my position as a learning assistant led me to pursue physics education research. The second chapter discusses my researcher positionality and how interaction analysis techniques address my research questions and sheds new light into my research areas. The first body chapter focuses on how tutorials may contribute to inequitable group dynamics. Even though we do not traditionally think of tutorial writers as instructors, they can spot harmful group

dynamics emerging in pilot testing of the tutorial and they should modify the tutorial accordingly. In the fourth body chapter, engineering Learning Assistants, undergraduate teaching assistants, address harmful group dynamics emerging in freshman-level engineering design teams. Role-plays in the LA pedagogy seminar make visible some of the harmful ideologies that constrain LAs diagnoses and proposed treatment of teamwork troubles, creating space for the LAs to discuss and challenge those harmful ideologies. I conclude by discussing insights which cut across both research spaces, including how equity is conceptualized and learning environment design.

A STUDY OF HOW INEQUITIES EMERGE IN INTERACTION IN UNDERGRADUATE PHYSICS AND ENGINEERING EDUCATION SPACES

by

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Dedication

I dedicate this dissertation to my K-12 teachers.

Through their care and passion, they have given me a lifelong hunger for learning.

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Statement of Co-Authorship

Chapter 3 of this dissertation is based on a previously co-authored journal article:

Sabo, H., and Elby, A. (2020). Rethinking the division of labor between tutorial writers and instructors with respect to fostering equitable team dynamics. Physical Review – Physics Education Research, 16, 020142.

The format of the work included has been altered to conform with standard dissertation format.

The dissertation examining committee has determined that Hannah Sabo has made substantial contributions to the jointly authored work warranting its inclusion in the dissertation.

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Chapter 1: My journey to physics education research

Introduction

While working on my dissertation, a guiding motivation for my pursuit education research emerged; my work broadly boils down to wanting to make classroom experiences better for learners. This moral intuition arose when I was an undergraduate learning assistant. In our pedagogy seminar, we learned about student-centered teaching methods, such as responsive teaching (Hammer, 1997; Robertson et al., 2015), as opposed to a misconceptions-oriented lens which takes a deficit view of students' thinking. Many who have come before me share this orientation, like bell hooks (Hooks, 2014), who takes a feminist approach to Paolo Freire's liberatory education (Freire, 2014). Dewey (1923) and Gloria Anzaldua (1999) also strove to make education more inclusive.

As a researcher on an engineering learning assistant project, this guiding principle developed. The pedagogy seminar focused on teaching and learning, engineering design thinking, and equity. As I read about equity in engineering classrooms, such as Erin Cech's description of ideological pillars in engineering, like the depoliticization of engineering work, which views public welfare as irrelevant to "real engineering work" and meritocratic ideologies, which frame current work structures as fair and just (Cech, 2014). Donna Riley discusses engineering mindsets, such as the myth of objectivity, commitment to problem solving, and narrow technical focus. These ideologies are prevalent not just in engineering culture, but in engineering classrooms (Riley, 2008). In this chapter, I describe how my experiences as a student, teacher, and researcher have shaped my journey in STEM education research, with specific focus on how that moral intuition has transformed throughout my journey.

Experiences as an undergraduate learning assistant

I was first introduced to physics (and discipline-based) education research as an undergraduate learning assistant at a small, liberal arts college. When I took physics, my class was taught in a small-groups interactive manner. I quickly adjusted and learned to prefer an interactive style over a lecture-based style and found that I retained information over the semester.

Although I found interactive learning to be more engaging than a traditional style, I also felt very vulnerable and exposed as I shared my ideas. I did not have a lot of intellectual status at my table, and I felt like I lost more each time I was incorrect. In her study on learned helplessness, Carol Dweck found that negative evaluation of girls' performance referred almost exclusively to girls' intellectual inadequacies (Dweck et al., 1978). The physics concepts took me a while to work through but came naturally to my group mates (who had taken physics before) – or so I thought; I felt helpless when I did not understand the concepts immediately, and I lost intellectual status within my group and confidence in myself to learn physics. I felt dependent on my groupmates.

In particular, the "replace your misconceptions-ridden" nature (as opposed to a refinement of a students' thinking and intuition (Smith III et al., 1994) of the instructional materials strongly contributed to my learned helplessness. After seeing my intuitions as inconsistent with reality, as physics pretends to be objective, repeatedly, I felt more and more beat down. I had not yet realized that there were methods of instruction that focused on refining rather than replacing my initial ideas.

At the end of the year, I was recruited to be a physics learning assistant (or an LA). Although I did not perceive myself as someone who was good at physics, I thought that I had the right skills to help others learn physics. While I was taking physics, I felt singled out as "not great at physics;" after I started LAing, I realized that many students shared my anxiety and lack of confidence, particularly the "learned helplessness" As an LA, I was also determined to reinforce my (perceived) lacking content. As I prepared to teach the concepts to other students, my confidence increased. I learned to trust my ability to figure things out.

Although my own experience of learned helplessness felt very personal, I realized that many students had similar experiences in the physics course. Students regularly expressed their lack of confidence in their own intuition, due to the framing of their thinking as misconceptions, and incompatible with "expert-like" thought. I later learned that these feelings of alienation and helpless are a widespread problem in physics and undergraduate STEM more generally (Diener & Dweck, 1980; Lising & Elby, 2005; Seymour & Hewitt, 1997).

Shifting my teaching to honor my students' ideas

One week, in my LA pedagogy seminar, we were given an assignment to explain why a students' incorrect idea made sense to them. After this assignment, I realized that this "seed" of correctness was a place where I could help the student build a more sophisticated understanding of the physics concept. I wanted my students to see the continuity between their ideas and "the canon of physics." I searched for "seeds" or student resources that could *grow* into an understanding of physics that aligned with "the expert". These seeds did not have to be conceptual (relating to a physics concept), or even canonical. They often had to do with noticing a student's careful, mechanistic account or related to scientific practices, such as designing experiments. During this project, I found myself committing to the seeds that my students brought to class. I wanted to help *their ideas* grow and flourish. The shift in my teaching led to my students feeling more confidence in their own thinking and empowered them to solve difficult problems. This method helped students see more connection between their lives and what they were learning in physics courses.

My pedagogy instructor, Amy Robertson, mentioned that she wanted to pursue resources in a research setting. I asked Amy if she would be my senior project mentor for this project. Together with Lisa Goodhew, we wrote a paper on conceptual resources that students had about energy (H. C. Sabo et al., 2016). I presented this work at the AAPT 2015 Summer Meeting and really enjoyed the environment.

Although the cognitive piece of the resources-method fascinates me, what I value most was the ways in which resource-centered instruction validated students and saw their experiences as helping, not hindering, their learning. Seeds/resources created a more humane alternative to the current physics instruction, which is what I truly valued in the teaching method and research. Researchers in science education have explicitly endorsed the importance of building on students' ways of thinking and knowing to prevent alienation, particularly of students underrepresented in STEM (Bang & Marin, 2015; Hammer et al., 2012; Rosebery et al., 2010).

Introductory physics PhET tutorial development

As I moved into my graduate career at the University of Maryland, I slowly decided to focus on creating more humane, equitable work environments. For my first two years, I developed and researched tutorials which used PhET simulations using research methods from my discourse analysis course. At first, my research questions focused on the shifts and stabilities in students' epistemic frames as they worked with the simulation and through the tutorial. As I observed a group of three students working through the *Orbital Mechanics* tutorial (which used My Solar System simulation. In my data, one of the students was asked by her groupmates to be in control of the computer. Although some researchers have found that being in control of the computer is a high-status position (Radermacher et al., 2014; Secules et al., 2018), in my data, the keyboard controller was placed into a more secretarial role and excluded from the intellectual & conceptual discussion. As an instructor, the exclusion of a group member troubled me. As someone who had experienced and witnessed the devaluation of my own and other's ideas, I was deeply bothered. I wanted to ensure that the tutorials that I wrote helped students' ideas be heard and honored, rather than dismissed. I could not ignore the harm that my tutorial had contributed to. So, I pivoted my project's focus from investigating the students' epistemic frames to the group's negotiation of work for the duration of the tutorial. Previous research supported the likely productivity of this pivot, as group dynamics, including how students position each other, has been found to greatly affect students' opportunities to learn (Barron, 2003; Conlin & Scherr, 2018; Esmonde, 2009).

Another student mistakenly accused Zoe of incorrectly setting up a simulation, and Zoe's lost status showed signs of persisting, even after the group discovered that Zoe had not make a mistake after all. Worse yet, there was evidence that that the wording of the written tutorial contributed to the mistaken accusation. In analyzing this episode, I will argue for physics education curriculum developers to be more transparent about how observations impact changes made to the tutorials. Finally, this chapter uses interaction analysis to propose changes to the classroom.

In chapter 3, I present my research on identifying the problematic dynamic and a call for curriculum developers to attend to teamwork/equity issues in development and to be more transparent about the changes to the tutorials that they make in the research that they publish on the topics.

Research on undergraduate engineering learning assistants

My four years as a learning assistant not only lead me not only to graduate school in science education research, but also to seek out opportunities working with learning assistants for my graduate assistantship.

My work on the undergraduate engineering learning assistant project at UMD provided opportunities for me to expand my thinking about equity. My own experiences in an LA program centered around pedagogy, studying the instructional techniques used by the worksheets, and helping students think conceptually. The engineering learning assistant program at UMD was focused on promoting design thinking, promoting productive teamwork, and addressing systemic inequities in engineering culture broadly. While my research on the PhET project focused on localized inequities emerging in a moment, my work on the engineering learning assistant project transformed my research interests to investigations of systemic and societal level inequities being reproduced in classroom contexts.

My second year on the project, the project team collected data in the learning assistant pedagogy seminar and wrote another conference proceedings paper. As we worked on the conference proceedings, we investigated how our engineering learning assistants produced, reproduced, or challenged technocracy and meritocracy in the context of the pedagogy seminar (Turpen et al., 2018). As I contributed to this paper, I became more familiar with technocracy, meritocracy, and the harm that they cause. For example, the LAs demonstrated the ability to reason complexly about the structure of teams and noticed how solving communication issues within the teams lead to technical progress; however, the LAs only saw the value of social solutions in the service of technical progress.

The following year, I worked with the team on another conference proceedings paper which allowed my thinking to evolve beyond seeing local harm. As the research team pursued this research, I oriented myself with the work of Donna Riley (2008), Erin Cech (2014), and Amy Slaton (2015). I started to see how ideologies such as technocracy and meritocracy caused harm. In another example, LAs describe team members who get excluded from work (and learning opportunities) on the OSV get referred to as "dead weight;" a term which gets picked up by other learning assistants (Turpen et al., 2019). I also started to see how these ideologies had been baked into the education that I had already received. From previous studies, I learned that these ideologies are widespread and harmful in engineering education, casting many students as "not cut out for" engineering, denigrating communication and other "soft skills" that professional engineers recognize as important to productive teamwork, and reinforcing alienation felt in particular by students from demographic groups underrepresented in STEM (Gunckel & Tolbert, 2018; Secules et al., 2018; Tonso, 2006).

For this dissertation, I choose to focus my work on a role-play which occurred during the second, 2018, iteration of the pedagogy seminar. In the role-play, one student, “Mike,” who has had good attendance, but is missing class because he is sick. During the role-play, the students find an error in his work; the LAs troubleshoot the OSV with the students and instruct them to redesign the circuit wiring. Initially, the LAs considered foregrounding the attendance issue, but when the deadline was introduced, they focused on the technical issue. However, they did not object when the “student” characters cut the absent student out of his own work. When the instructor asks the LAs how Mike will feel when he comes back to class and the students have changed his design, the LAs resist this question – there was a major error in his work; they suggest that if Mike was a reasonable person, he would understand the changes and not have his feelings be hurt.

This example highlights two issues resulting from the upcoming deadline. The deadline causes the LAs and students to weigh the vehicle completion over Mike’s learning opportunities, which would be reasonable to value in a course about engineering design. Furthermore, when responding to how Mike might feel, the LAs respond saying that if he was a reasonable person, he would not mind it, despite that Mike would likely consider this a bad experience working with his group.

Structure of the dissertation

My dissertation was written as two self-contained papers and rather than follow the traditional dissertation model. The following chapter discusses how my research methods, interaction analysis, address my research questions and provide novel insights to the fields of physics and engineering education research. Body chapter 3 focuses on how a worksheet contributes to the production of an inequitable team dynamic. Body chapter 4 investigates how a product- and deadline-focused culture collapses learning assistants' interpretive frames. Finally, the dissertation ends with some connections across both chapters and implications from the work.

Chapter Three proposes the rethinking of the division of labor between Physics Education Research (PER) curriculum developers and classroom instructors. Historically, both curriculum developers and instructors have taken responsibility for fostering students' conceptual development, epistemological development, and other learning goals related to physics content knowledge and practices/process skills. By contrast, responsibility for fostering productive group dynamics has been taken up almost entirely by instructors. Tutorial and lab developers structure their materials to be used in small groups, but have not generally designed, tested, and refined their materials to minimize problematic group dynamics. In this paper, **Rethinking the division of labor between tutorial writers and instructors with respect to fostering equitable team dynamics,** Dr Andrew Elby and I argue that the written tutorial can and should do more to prevent negative group dynamics from arising. To make this claim plausible, we describe an example from our own experience. While revising a tutorial, we noticed some problematic dynamics emerging; one of the students was unfairly blamed for a simulation-setting mistake and was later left out of a conversation. We came up with hypotheses about factors that might have contributed to those dynamics. A few of those factors, we argue, could be addressed in part through tutorial revision. So, while acknowledging that instructors will always have more capacity and hence more responsibility than curriculum writers to foster productive group dynamics, we call for tutorial writers, during the testing and revision of their materials, to monitor how the tutorial impacts team dynamics and to be transparent (in publications and presentations) about how they modified the tutorial to address problematic dynamics they observed.

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Chapter 4 (engineering learning assistant chapter) investigates how Learning Assistants (LAs) contend with both social and technical issues in semi-improvised (guided by a prompt) role-plays and post-role-play discussions. Technocracy, a problematic world view that values technical abilities and solutions over social ones, pervades engineering. I draw on audio-video records of a role-play and following discussion from our pedagogy seminar in which LAs, playing as students or an LA, had to contend with both social and technical issues. Using tools from discourse analysis, I analyze how technocracy is both reproduced and challenged during the roleplay and following class discussion. The discussion allowed the LAs to reflect on their assumptions and decisions during the role-play. Mundane aspects of engineering design courses (such as deadlines and group work in which not everyone is present every time) create conditions that favor the product over the process (such as taking away students' learning opportunities), despite the purpose of such courses to teach design thinking.

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Chapter 2: Methods

Introduction

As described in chapter one, my own experiences of and witnessing marginalization firsthand in STEM courses orient my research interests towards understanding human experiences. As I learned more about physics education research, I learned that my experiences were common (Barthelemy et al., 2016; Diener & Dweck, 1980; Lising & Elby, 2005; Seymour & Hewitt, 1997).

Although survey methods can yield information on the pervasiveness of inequities in STEM education and interviews can shed light into their impact, it is important to study the moment-to-moment interactions to better understand students' lived experiences in STEM courses. In particular, it is important to know how local inequities emerge so that we can design learning spaces to mitigate this harm.

Interactional sociolinguistics, a branch of discourse analysis, investigates how meaning is constructed in interactions. It provides an analytic lens to better understand students' (and learning assistants') experiences. In this chapter, I describe how interaction analysis allows me to answer my research questions. I want my research to capture the mundane, lived experiences that students in STEM courses face.

Researcher Positionality

My dissertation contains data from two research projects. The first, which I call "the PhET project," used iterative design to develop tutorials which accompany PhET Simulations (*PhET: Free Online Physics, Chemistry, Biology, Earth Science and Math Simulations*, n.d.) and to research how those tutorials impacted students. Before I joined the project, several tutorials had already been drafted. When I started, I was the only research assistant on the project. In that role, I wrote and tested the remaining tutorials. I met weekly with Dr. Andrew Elby, who provided feedback on drafts of tutorials and data that I brought to him. As the main researcher on the project, I took the initiative to re-orient the research lens to focus on (un)productive patterns in students' group work when using the simulation. I also selected the analytic methodology.

The second body chapter contains data from the "Engineering Learning Assistant" project, which was a collaborative, large research project. The project implemented, researched, and revised iterations of a pedagogy seminar for engineering learning assistants. The pedagogy seminar equipped undergraduate teaching assistants with engineering- and equity-oriented pedagogical instruction. Between iterations of the pedagogy seminar, the team collaboratively revised the pedagogy seminar. One researcher on this team taught the pedagogy seminar. A postdoctoral scholar, Dr. Jennifer Radoff primarily collected the data, however, I did some of the data collection. This team has published several conference papers, which I contributed to. For my dissertation, I selected a subset of this data to investigate; the work in chapter four is largely my own intellectual scholarship.

As a white woman in STEM, I have been on the receiving end of gender-based microaggressions. I do not and never will know what it is like to be at the receiving end of race-based, or intersectional gender-and-race-based microaggressions or aggressions. My own experiences of marginalization have sensitized me to "see" threats of marginalization in discourse and to choose data and research methods to capture those experiences. It is critical that I elevate the voices and experiences of my research participants.

My data and discourse analysis

Because my dissertation is following a separate-chapters model, each body chapter includes its own methods section, including descriptions of the data and its contexts. However, for my research contexts and DBER (discipline-based education research) subfields, discourse analysis, particularly interaction analysis, is an unusual way to look at the data which are primarily used to inform improvements to curriculum and instruction. So, these dissertation chapters illustrate how to expand the range of methods used to explore inequities in engineering and physics learning contexts in the service of instructional improvement.

My first body chapter presents an argument that curriculum developers should attend to the interactional dynamics which their curriculum creates. Physics education research as a field has put a lot of effort into developing and improving tutorials (L. C. McDermott et al., 1994; L. C. McDermott & Shaffer, 1992; Shaffer & McDermott, 1992). More information on research methods for tutorial development in physics education research can be seen in the literature review in chapter three. Physics tutorials have normally been improved with pre-post surveys and interviews. In research, observations of the tutorials have been used to adjust the "flow" of the tutorial. However, in the PER subfield, it is unheard of to use a careful, turn-by-turn discourse analysis to inform the improvements that are made to the tutorial. Interactional sociolinguistics brings a new lens to tutorial development in physics education research.

My second body chapter investigates how role-plays can help peer educators grapple with social and technical issues. Role-plays are a common teaching strategy, especially in training educators. However, research questions usually investigate what students "got out" of role-plays such as practice teaching. It is unusual to look carefully at what emerged in the interaction, as opposed to what the students "come away" from the role-play with. In my second body chapter, interaction analysis allows me to see how learning assistants challenge or uphold harmful cultural narratives/assumptions as they make decisions on what to prioritize during the role-play (and following discussions).

What is interactional sociolinguistics?

Interactional sociolinguistics is a branch of discourse analysis which investigates how meaning is generated by looking at interactions and the contexts in which they occur, especially by investigating the speech (and body language) within these contexts. It is a qualitative method of discourse analysis that draws from linguistics, anthropology, and sociology. The method emerged primarily from the work of John J. Gumperz in the 1960s and 1970s (Gordon, 2010).

Interactional sociolinguistics draws on several types of discourse analysis. It draws most heavily from conversation analysis but is also informed by the context that events occurred in, rather than just the communicative acts themselves. Specifically, interactional sociolinguistics draws upon ethnographic techniques to understand how conversations interact with cultural knowledge and behavior. Ethnographic techniques typically incorporate observation and description of the context surrounding the research findings (directly opposed to conversation analysis, where only the transcribed conversation is referenced).

Conversation analysis was collaboratively developed by Harvey Sacks, Emanuel Schegloff, and Gail Jefferson in the 1960s. In *Conversation Analysis*, Goodwin and Heritage (1990) detail how conversation analysis investigates elements of conversations such as utterances, preferences, turn-taking, feedback, repair, conversational openings/closures. Conversation analysis connects conversation to underlying social and cultural constructs, conceived of as social rules. However, with conversation analysis, a researcher's analysis is limited to only what is present on the transcript.

Analytic tools and how they answer my research questions

Interactional sociolinguistics, the heart of which is conversation analysis, provides techniques to investigate how meaning in conversations is constructed. These techniques help investigate both group dynamics and learning assistants' reasoning around group tensions. My analyses in chapters 3 and 4 make particularly heavy use of the following two constructs.

Turn-taking and orienting

Conversations are organized into turns, where one person speaks and another listens. When the speaker is done speaking, they signal for the next person to take a turn (Sacks et al., 1978). In conversation analysis, the meaning of a previous turn is determined by how it is responded (or oriented) to; the reaction to the statement defines the meaning of the statement, irrespective of the speaker's intent.

Status within groups can be determined by identifying who speaks, for how long, and who is invited to speak. Furthermore, in some cases, the response to a previous turn may be not to take up those ideas or to signal to a person that it was not their turn to talk. In analyzing turns, I can identify status within groups. I can determine whose ideas take up space in the conversation and whose ideas get ignored.

Positioning

Positioning theory describes the implicit and explicit patterns of reasoning based on conversation participants beliefs about the rights and responsibilities of themselves and others (Harré et al., 2009; Van Langenhove & Harré, 1999). These beliefs are realized in the participants' expectations of and actions towards themselves and one another. Positioning occurs during interactions, so it is studied through discursive analysis (Harré et al., 2009). These positions can be both formal and assigned, such as an instructor being positioned as an instructor, or informal, such as positioning someone as an expert.

Positioning analysis allows local power in an interaction to be discerned and described (Harré & Slocum, 2003). Different positions entail different "rights" or powers. Furthermore, people often position themselves and others relative to different groups. Broader societal biases, such as racism and sexism, underlie the positions that are available for people to take. Since positions assign available rights and restrict the opportunities available to conversation participants, positions give and constrain participants' power in local interactions. By studying how people are positioned by themselves and others in discourse, I can determine where local power lies.

Framing

Framings are alignments or shared understandings that people take up when talking to one another—specifically, shared understandings of "what is it that's going on here?" (Goffman, 1974) and accompanying expectations about what kinds of speech and actions are invited (Tannen, 1993). A framing-oriented analysis investigates how situations are defined by participants both explicitly in their speech and implicitly in their actions, to try to determine what types of activities speakers are engaged in as they communicate. As interactions progress and new information emerges, participants' interpretations of situations can shift; framing analysis makes it possible to capture both shifts and stabilities in participants' understanding of what they are doing.

In the PhET chapter, I use framing and status considerations (see above) to see how students position themselves and others during group work. As they work, I investigate what contributions they offer and what they expect of their team members. In the engineering learning assistant chapter, I investigate how the learning assistants frame issues which arise from a role-play scenario, both explicitly as they talk about the problems and tacitly as they propose instructional moves.

Conclusion

Interaction analysis allows me to study natural interactions that occur in STEM learning environments. The study of these interactions illustrates students' day-to-day experiences and provides insight into how inequities emerge in moment-to-moment interactions.

Chapter 3: Rethinking the division of labor between tutorial writers and instructors with respect to fostering equitable team dynamics

Introduction

This paper argues for rethinking one aspect of the instructional division of labor between curriculum developers and classroom instructors. Generally, the curriculum developer (tutorial author, lab author, or activity sheet writer) and the instructor (or facilitator) share responsibility for fostering students' conceptual and/or epistemological development. By contrast, in PER, we generally assume that the instructor takes sole or primary responsibility for fostering good team dynamics, as represented in Figure 3.1. We advocate for curriculum developers to attend to the kinds of conversations their activity sheets afford—not just at the coarse grain size of encouraging group discussion, but also at a finer grain size.

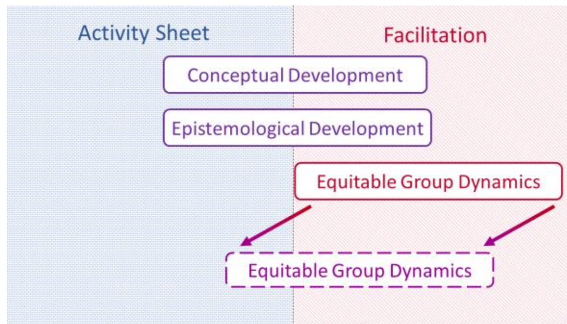


Figure 3.1 Division of labor between activity sheet developers and classroom facilitators. We argue that developers should take on a greater share of responsibility for fostering equitable team dynamics.

To illustrate both the feasibility and value of attending to subtle effects of question sequencing and wording on student group dynamics, we analyze a segment of student discourse from their work through a draft of a PhET-based tutorial. Our tutorial, we argue, contributes to an inequitable teamwork dynamic, but can be revised in ways that could reduce the risk of these inequitable dynamics arising. To illustrate how we spotted what we thought were problematic dynamics, we present transcript of the relevant segments of student conversation and describe what the first author noticed in real time as an observer. Then we check this quick, informal analysis against a second, in-depth interaction analysis. We then discuss how these analyses suggest possible revisions to the tutorial that could help address the problematic dynamic. In our example, the outcome of running the PhET simulation deviates so dramatically from the students' expectations that they think the person controlling the computer, Zoe, set up the simulation incorrectly. She gets blamed despite having set up the simulation correctly. Our ideas for tutorial revisions to mitigate this kind of dynamic might or might not work; like any potential tutorial revisions, they would need to be tested and refined in the usual iterative cycle by which tutorials are improved. Our point is simply that fostering equitable group dynamics, like fostering conceptual development, should be an outcome that curriculum developers pursue during the iterative refinement process.

Before diving into our example, however, we need to situate our argument in the literature by analyzing what data and learning outcomes other tutorial developers have foregrounded in their tutorial assessments. We assume the outcomes that were assessed also helped to drive the tutorial revision process, though of course other outcomes might have been monitored as well, formally or informally.

Literature Review: What outcomes drive tutorial assessment?

This literature review serves two purposes. First, it provides an overview of the learning outcomes assessed by researchers and the methods used to assess them during the revision and testing phases, as reported in researchers' published work. This is meant to serve as a resource, particularly for new PER scholars getting into tutorial development and wishing to situate their work within that literature. Second the literature review supports our argument that tutorial developers have not reported observing group dynamics and making revisions aimed at improving those dynamics (though we suspect tutorial developers do so informally).

For the purpose of this paper, we define "tutorial" broadly as a guided activity sheet aimed at teaching physics concepts and/or practices through a process of small-group inquiry. So, labs and invention tasks less guided than typical tutorials are still "tutorials."

We primarily investigate the learning outcomes targeted during tutorial design, showing that most developers target conceptual understanding—typically from a misconceptions or student-difficulties perspective—and/or other cognitive constructs such as epistemological growth. We also explore the research/evaluation methods authors use to inform revisions. We argue that the most common research designs, namely pre-post testing, treatment vs. comparison groups, and interviews (other than think-aloud protocols), provide a limited window into students' learning *processes* while working through the tutorial, including the role of group dynamics. These methods thereby restrict the nature of the tutorial revisions that the research can inform. None of the papers we reviewed targeted productive group dynamics as a learning outcome or included observations of students' working through the tutorial as data.

Literature review methods

Due to the specialized nature of physics education research, we selected journals and conference proceedings targeted at physics and science education research rather than searching a large database. We acknowledge that many other DBER communities also conduct research and development on activity sheets designed for collaborative active learning; however, the PER tutorial development community has not drawn extensively on this work. Rather than looking outward, we turn our focus inward, on tutorial development within the PER community.

In our search, we included the following journals: PRST-PER/PRPER, PERC Proceedings, American Journal of Physics, The Physics Teacher, Cognition & Instruction, Journal of Research in Science Teaching, Physics Education, and the Journal of the Learning Sciences. To be included, the research had to address tutorial(s), question sequence(s), or question types aimed at undergraduate, introductory physics students. The exception to this (Elby, 2001) which discusses a paired-question technique later deployed in introductory undergraduate physics tutorials (Redish & Hammer, 2009). We did not include papers on upper-division physics tutorials, though an informal scan through that literature suggested that the patterns documented below apply to the upper-division tutorial literature, too. Twenty-five articles, all reporting empirical studies, fit our selection criteria. For a full list of the literature included in this review, see Appendix A.

As we read each article, we focused on what constructs and associated learning outcomes the authors oriented to in the process of tutorial design, such as conceptual correctness or epistemological sophistication. We also focused on how the researchers assessed the tutorials' effectiveness. Because none of the papers reported on the messy details of the tutorial refinement process, we cannot know for sure whether *other* constructs and learning outcomes were also targeted during the refinement process. Still, we can reasonably infer that the reported targets of assessment were likely foregrounded during the refinement process. We return to this point below.

Literature review findings

Of the twenty-five articles we identified, twenty-two focused on refinement of at least one tutorial. One addressed a full course redesign (Redish & Hammer, 2009), and two addressed specific types of questions (Elby, 2001; Hu & Rebello, 2014).

In terms of learning outcomes, twenty-two were focused on conceptual change, fourteen of which took a misconceptions- or student difficulties-oriented approach to tutorial design. Three papers focused on epistemology. Throughout this literature review, we highlight these patterns in the research methods and in the assessed constructs/outcomes. To show the range of studies, we also describe in more detail some of the studies that break from these patterns.

1. Assessed Constructs & Learning Outcomes: Conceptual Change Focused Tutorials

All but three articles assessed conceptual change, though several also explored other learning outcomes, as discussed below. Most of these studies used pre-post testing, sometimes in conjunction with other methods, to determine the students' conceptual growth (Ambrose et al., 1999; Chang & Shaffer, 2018; Chase et al., 2010; Close et al., 2013; Cochran & Heron, 2006; Elby, 2001; Heron et al., 2003; Isvan & Singh, 2007; Kautz et al., 2005; Kuo & Wieman, 2015; Lindsey et al., 2009; Shemwell et al., 2015). To pre-post test, researchers administer a written assessment, typically one or more qualitative conceptual physics question, before and after students complete the tutorial to see how students' responses improve, and then revise the tutorial as needed. This cycle is often repeated for several iterations. Sometimes, as a last step, tutorial authors test the tutorial in contexts outside of the initial course. For example, after Wosilait et al. (1999) first tested the tutorial in the calculus-based course, then they tested it in the UW algebra-based course and at other universities and two-year colleges.

In terms of the strategies employed by the tutorials to foster conceptual growth, most of the studies fell into one of three categories, discussed in the next three subsections.

(a) Eliciting, confronting, and resolving misconceptions.

From the early 1990s, three articles from the University of Washington detail the Physics Education Group's process of curriculum design (L. C. McDermott et al., 1994; Shaffer & McDermott, 1992, 1992). Their tutorials are designed for discussion sections of large lecture courses, though they can and have been used in other settings. Many later studies followed the same process (Ambrose et al., 1999; Chang & Shaffer, 2018; Close et al., 2013; Cochran & Heron, 2006; Guisasola et al., 2010; Heron et al., 2003; Isvan & Singh, 2007; Kautz et al., 2005; Lindsey et al., 2009; Wosilait et al., 1998, 1999). Before designing the tutorial, the researcher-authors either investigate common student difficulties around a topic or look up previously researched misconceptions. The authors then write a tutorial usually incorporating at least one "elicit, confront, resolve" sequence (L. C. McDermott & Shaffer, 1992; Shaffer & McDermott, 1992). This sequence starts by asking students a specific, contextualized physics question that is likely to elicit a misconception or student difficulty. The next step involves helping students spot a conflict between their conception and a phenomenon or other conception. Finally, the tutorial tries to help students reach a satisfying resolution of the conflict.

(b) Scaffolding

Some researchers explored how the degree or type of guidance and scaffolding included in the tutorial impacted students' conceptual gains. For instance, Lindstrøm & Sharma (2011) created a series of activities which included a summary of the lecture, were given a concept map, and standard quantitative problems. They compared these tutorials to the less guided approach of their traditional recitation section, which included the same word problems only. Several other tutorial designers focused on assessing the role of a particular analogy in helping students learn (Bao & Redish, 2002; Kuo & Wieman, 2015; Lin & Singh, 2015). For example, Kuo & Weiman (2015) designed a tutorial to guide students in learning to read off the electric field from an electric potential map, using an analogy to reading off the slope of the ground from a topographical map.

When testing the efficacy of a given type of scaffolding, researchers often divide students into comparison groups, consisting groups receiving the scaffolded tutorial vs. traditional instruction, or tutorial A vs. tutorial B, or the old vs. new version of the same tutorial (to evaluate refinements), or tutorial A vs. another task. Researchers compare how the two groups perform, usually on a conceptual assessment. Many authors employed the comparison groups strategy, either in addition to or instead of pre-post testing (Bao & Redish, 2002; Chase et al., 2010; Cochran & Heron, 2006; Gette et al., 2018; Guisasola et al., 2010; Heron et al., 2003; Isvan & Singh, 2007; Kuo & Wieman, 2015; Lin & Singh, 2015; Lindstrøm & Sharma, 2011; L. C. McDermott et al., 1994; Podolefsky et al., 2013; Shaffer & McDermott, 1992; Shemwell et al., 2015).

(c) General rule vs. contrasting casts

Some studies used comparison groups to contrast the benefits of different cognitive processes. They also compared the scaffolding designed to support those processes (Chase et al., 2010; Kuo & Wieman, 2015; Shemwell et al., 2015). Within a given study, one tutorial follows the predict-observe-explain model for various, individual cases, such as a wire loop getting pushed into a region of constant magnetic field and a stationary wire loop in a region of steadily increasing magnetic field. The other tutorial presents all the cases up front and asks students to generate a rule to explain all the phenomenon. The researchers hypothesized, and found, that students using the "generate a rule" tutorial would orient to the deep structure of the topic rather than the surface features of the cases, achieving greater conceptual understanding (Chase et al., 2010; Shemwell et al., 2015).

2. Other assessed constructs & learning outcomes

We now turn to the smaller number of studies that focused primarily on constructs other than conceptual understanding, starting with tutorial-based studies of cognitive processes.

(a) Student cognition

The General Rule vs. Contrasting Cases studies we just described could be viewed as examples of this, since their point was to test a hypothesis about the utility of a particular cognitive activity, "general rule" creation. However, those studies looked at students' pre-post test gains. Many studies instead used various types of interviews with students, to probe their depth of understanding or their type of reasoning. For instance, Gette, Kryjevskaia, Stetzer, & Heron (2018) considered student cognition, specifically dual processing theory, to inform their tutorial design. The authors found that students' difficulties might emerge not from a gap in their conceptual understanding, but rather, from responding based solely on their quick, "commons sense" response. According to dual processing theory, when a reasoner is presented with a problem, they have a quick gut-level response and sometimes, a slower, scrutinizing process where they check and if necessary, correct their gut-level response (Groves & Thompson, 1970). If the thinker has no reason to question their gut-level reaction, they won't scrutinize it. Working from the assumption that some student difficulties stem from failure to engage in such scrutinizing, Gette et al. used think-aloud interviews to collect students' reasoning while working through a tutorial. Coding the transcripts into gut-level responses vs. slower scrutinizations (when possible), the authors identified tutorial sections that failed to elicit slower scrutiny of students' gut level responses and revised the tutorial accordingly.

(b) Student preference

In addition to investigating effects of heavily-scaffolded versus unscaffolded tutorials (see above), Lindstrøm & Sharma asked students which type of tutorial—their reformed tutorial or traditional workshops—they preferred and what they liked and disliked about each option (Lindstrøm & Sharma, 2011). (They found that students preferred their more structured approach to traditional quantitative problems.) Additionally, they studied students' attendance patterns, finding that some students switched from traditional workshops to the more scaffolded workshop, but not vice versa.

(c) Epistemology-focused tutorials

Three articles focused on creating curriculum to develop students' epistemology rather than (or in addition to) their conceptual understanding. Redish & Hammer (2009) describe a course redesign that included designing tutorials aimed at refining students' epistemology and assessed using the Maryland Physics Expectations Survey, probing students' beliefs about what counts as learning and understanding in their physics class. Conceptual developmental was also assessed. Elby (2001) and Hu & Rebello (2014) did not describe the design of a specific tutorial, focusing instead on how aspects of the question design helped students gain a more sophisticated epistemology of physics. Hu & Rebello interviewed each small group of their student participants twice. In one interview, the student group worked through a physics problem (Hu & Rebello, 2014). In the other interview, students considered a similar problem scenario but in the context of evaluating a hypothetical student debate where the hypothetical students approach the problem differently. Analyzing the videotaped interviews, the authors compared students' framing of their problem-solving—e.g., as "plug and chug" versus mapping physical meaning onto math—to the epistemological views expressed while evaluating the hypothetical debate. This analysis enabled the authors to look for variations in student epistemologies based on task structure, which informs instruction aimed at tapping into the more sophisticated aspects of students' epistemologies.

Literature Review Conclusion

In summary, most published work on introductory physics tutorial development focuses on conceptual development, using pre-post testing and/or comparison groups to evaluate the tutorial's efficacy and to inform revisions. Several researchers also incorporated interviews, but not as the main assessment technique. Two researchers used interviews to evaluate students' cognitive processes (Gette et al., 2018) or their framing of the tasks (Hu & Rebello, 2014). Both Gette et al. and Hu & Rebello's work were published in the last six years. Perhaps assessment methods are broadening to focus more on learning processes rather than just before-and-after snapshots.

Furthermore, over the last 20 years, researchers have expanded the range of learning outcomes assessed to include not just conceptual development but also epistemologies and other constructs. Yet, a hole in the literature remains. Although productive group dynamics are needed to ensure that all students have the opportunity to benefit from a tutorial, and although tutorial advocates may take for granted that doing tutorials can help students develop communication and teamwork skills, these "soft skills" and group dynamics are not assessed and addressed in the published research.

We're not saying that tutorial developers ignore group dynamics. Indeed, we know from personal experience and from discussions with other research teams that tutorial developers often observe students working on their tutorials (sometimes while serving as an instructor or TA), noticing the productive and unproductive group dynamics that arise. Maybe they revise the tutorial based in part on these observations. But if so, they don't report on these observations of group dynamics and the associated tutorial revisions in their published work.

We posit that tutorials can contribute to promoting equity or to (re)producing inequity in group dynamics, in the sense of disrupting vs. contributing to marginalization of group members—marginalization that is particularly pernicious if it reproduces broader patterns of marginalization in physics and in society, since a mechanism by which marginalizing cultural narratives and power imbalances get stabilized is through their reproduction in numerous local interactions (R. McDermott & Varenne, 2018). Therefore, we argue, tutorial writers should attend to how the tutorial interacts with team dynamics. In the following sections, we show how a tutorial contributes to an inequitable interactional dynamic. We first show a moment that raised a red flag, and then provide an in-depth analysis of the video of the interaction to show that inequity between group mates did occur. We then detail some tutorial revisions that could perhaps prevent similar inequities from arising again. In this way, we argue that it's feasible and potentially productive for tutorial writers to analyze group dynamics in order to inform the revision of tutorials.

Theoretical and methodological orientation

Theoretical commitments central to our argument

In this paper, we do not adopt a theoretical framework for understanding student cognition and learning. The assumptions about learning on which our argument relies are simply that collaborative learning is likely to produce deeper learning of disciplinary concepts, deeper engagement in disciplinary practices, and deeper identification with the discipline when the group dynamics allow all students to participate, produce a range of ideas that are respectfully discussed and debated, and help all participants feel like they belong in the group. These assumptions are consistent with all learning theories of which we are aware and are supported by a range of studies undertaken from various theoretical perspectives (Barron, 2000; Cohen, 1994; Docherty, 2018).

To the extent we have theoretical commitments, they are of the type discussed in curriculum theory and foundations of education courses, which address questions like what "counts" as curriculum and what is the purpose of schooling (Pinar, 2004). We think the so-called "soft" skills that student can develop through collaborative active learning, such as close listening, communication of ideas, respectful interactions, etc., are important learning objectives, just as important as the physics concepts and "hard" problem-solving skills that physics curricular materials typically target more explicitly. We also think that fostering such skills is in the purview of curriculum (including written tutorials) as well as in the purview of instruction. So, assuming tutorial revisions *can* improve group dynamics—an assumption we put forth without proof in hopes that we and other research groups will explore it in the future—then tutorial writers should consider how the structure or wording of a tutorial might contribute to patterns of problematic group dynamics revealed by clinical or classroom-based testing, and should try out revisions when possible.

Methodological orientation of our illustrative example

In this paper, we're arguing that it's feasible and productive for tutorial writers to

(i) observe the group dynamics of students working through a draft tutorial,

(ii) notice episodes or patterns of unproductive group dynamics,

(iii) generate informal hypotheses about how the tutorial itself might be contributing to those dynamics, and

(iv) generate potential revisions to the tutorial, some or all of which could be tested in later versions of the tutorial.

If video or detailed field notes of the observed group are collected, steps (ii) and (iii) can be done more carefully, as we'll illustrate below. However, even if the tutorial writer's real-time observation of the tutorial group is all the "data" available, steps (ii) and (iii) are still possible—again, as we'll illustrate below.

In "seeing" problematic group dynamics and in formulating possible fixes, the tutorial writer inevitably brings in their explicit and/or tacit theoretical and methodological orientation toward analyzing such dynamics. For this reason, we now describe the methodology with which the first author was approaching this data in her research. We do so not to advocate for this particular methodology, but simply to help readers understand our own orientations.

Interactional sociolinguistics is a branch of discourse analysis which investigates how meaning is generated by looking at interactions and the contexts in which they occur, especially by investigating the speech that occurs. Our analysis incorporates not only the interactions among students, but also the interactions between students and the PhET simulation, and between students and the printed tutorial.

Framing, one of the focuses of interactional sociolinguistics, investigates how situations are defined by participants—e.g., a student's view of "what is it that's going on here?"—and how those framings both shape and are shaped by the participants' interactions (Goffman, 1974; Tannen, 1993). Within a given shared framing, distinct roles can emerge and can be taken on by students. Since these different roles have different rights and responsibilities, the roles students take on filter their interactions with each other and with the tutorial. The role of *keyboard controller*, the student who holds the keyboard and mouse and hence controls the simulation, will play a role (no pun intended) in our analysis below.

Below, we analyze two segments of interaction that the first author flagged in real time as problematic. We analyze each segment twice. The first, quick analysis rehashes what the first author noticed in real time, mirroring what a tutorial instructor observing the group can see. The second analysis uses video we collected (for research purposes) to take a deeper look at the interaction. In this paper the point of doing so isn't to generate new insights that contribute to research, but rather, to confirm, disconfirm, and/or flesh out the quick analysis. Tutorial writers who happen to be collecting research data would be able to do this kind of "second look" (re)analysis. The transcripts for these second-look analyses use Waring's conversation analytic transcription conventions (Waring, 2015), available in Appendix C, to capture pauses, particularly loud or soft talk, rushed or halting pacing, and so on. In these transcripts and descriptions, we try to include enough information for the reader to draw their own conclusions about the interaction, not just the information relevant to the points that we make (R. P. McDermott et al., 1978).

Background information: participants and context

In this section, we provide relevant details about the students and context of the interactions discussed below. Three students from the University of Maryland's Introductory Physics for Life Sciences (IPLS) courses were invited to participate in research interviews through email; the students received a financial compensation for their time. Three students were invited to participate in this interview: Zoe, who presents as a Black woman; Jonathan, who presents as an East Asian man; and Devran who presents as a South Asian man. All of the names are pseudonyms. Because the data was collected for tutorial-revision purposes, we do not have more information about the participants available.

In this session, the students were each given a copy of a tutorial covering the concept of gravity on a planetary scale (see Appendix B). This tutorial's format and flow were like tutorials students had previously used in the class; however, they had not yet covered this topic. The students were asked to engage in the simulation while working on the tutorial as a group. The observer (the first author) watched the students and took field notes as they worked. If the participants had a question about the tutorial or needed clarification of concepts, the observer took on the role of a teaching assistant. After the students had worked on the activity for 40 minutes, the observer engaged the participants in a conversation about their experience of the activity and the simulation. For example, "What was the simulation like?" and "What was it like working on the tutorial with another student?" and about any specific instances marked in the field notes. The interviews were video-recorded; Camtasia software simultaneously recorded the students and the computer screen (*TechSmith Camtasia | Screen Recorder & Video Editor*, n.d.). One additional camera captured the students and the observer.

Illustrative example: tutorial contributing to problematic dynamics

Watching the student group in person, the first author had her instructor and curriculum developer hat on, and same goes for the second author upon first viewing the video footage; we were looking for parts of the tutorial that needed revision. During this initial scan, we noticed a red flag. Zoe, who was in control of the keyboard and computer, was blamed (incorrectly!) for choosing the wrong settings in the simulation; and not long afterward, she seemed to be left out of the conceptual conversation around the tutorial prompts. In this section, we first describe how we noticed the red flag during an initial watch. Then, we discuss a deeper analysis which confirms the moment to be problematic. In the quick-look presentation below, we rely on transcript rather than our memories of what the students said, so that readers can hear—or rather, read— what we heard.

Initial Observation

1. Laying the blame

Within the first few seconds of the tutorial starting, Jonathan asked Zoe, "Do you wanna use the computer cause you're closest?" Zoe agreed to use the computer. The students seemed to develop roles, including managing the computer, a role Zoe played throughout the session.

Later, the tutorial instructed students to use the "ellipses" setting in the My Solar System PhET simulation (*My Solar System*, n.d.). The question the students responded to follows:

Go to the ellipses preset. Change the initial velocities of each of the planets to zero.

1) *Predict what will happen when you run the simulation. Explicitly compare bodies to each other. Explain your reasoning.*

2) *Run the simulation.*
    i) *Describe what happened to each of the three small bodies.*
    ii) *Is this this what you expected? Why did it behave this way?*

The purpose of this activity was to see how different radii impacted the motion (and therefore the gravitational force and resulting acceleration). The following moment occurred as Zoe, Devran, and Jonathan checked their prediction.

Transcript 1: Quick look

1	Z	Alright, do I do this now?
2	J	Sure. Hit it.
3	D/J	(*Devran and Jonathan move from looking at their handouts to looking*
4		*up and facing the computer screen*)
5	Z	(*Zoe starts to run the simulation*)
6	D	(*Devran leans forward*)
7		(*All three students look at the computer and watch for a few seconds*)
8	D	Oh. Wow. Uhh
9	J	(*Jonathan laughs*)
10	D	completely wrong. ((*Devran smiles*)) They just all go into the sun.
11	Z	(*laughs*) I really thought it was going to go around in a circle.
12		(*hearty laughter*) I also thought thats what an ellipse was, but I guess?
13	J	Wow. Wait, did we pick ellipse, Is that what that (*points at computer*
14		*screen*)
15	Z	Oh. When did that happen? I really-
16	J	we just killed three bodies. Three
17	Z	Oh no (*Zoe resets the simulation*)
18	D	*indistinguishable*-
19	Z	Ah. Why did I do that!
20	J	It's all good
21	Z	Well
22	D	Just change the velocity to zero. (*Devran sits up from the table, then*
23		*leans back into his chair*)
24		(*Jonathan sits up and leans back at the same time as Devran*)
25	Z	Clearly I’ve had a long day (*resetting the simulation*)
26	J	(*Jonathan laughs, nods, and sits forward*)
27		(a few second pause)
28	D	Actually, no wait, that’s what it was before.
29	J	Hm. Change the-
30	Z	that's when we changed it to zero. (*still using the computer to reset the*
31		*simulation*)
32	D	Yea, we changed it to zero, that’s what’s gonna happen.
33	Z	(*Zoe resets the simulation*) This is what should happen (*runs the*
		simulation)
34		(The computer shows the three bodies orbiting the sun)
35	D	No, but see. That makes sense because there was initial velocity before.
36		There was, Um, it's already moving in a direction, so the force is going
37		to influence it, but it's not going to go straight into the sun. But if you
38		put all velocities to zero then the

39	Z	Oh.
40	D	gravitational force on those masses- (*Devran moves from facing straight*
41		*forward to turning and facing Jonathan*)
42		(*Jonathan and Zoe look at Devran while he is talking*)
43	J	Yea it's just going to collide (*moves his left fist into his right palm*
44	D	(*overlapping with Jonathan*) yea. it's just going to go straight to it
45	Z	Oh, so, it was correct=
46	J	Uhm. (*Devran's gaze moves to Zoe, he does not turn his head)*
47	Z	because it changed back
48	D	(*Jonathan looks at Zoe*) No, you were right. We did it right the first time.

Jonathan, Devran, and Zoe predicted that the planets would orbit the sun. Instead, the planets fell straight into the sun. As tutorial writers, we had not intended this to be a surprise. We had wanted students to focus on how the planets' distance from the sun, for equally massive planets, affected the gravitational force exerted on them and the resulting motion. Instead of discussing this issue, the students realized that the initial velocity of the planets is what allows for them to orbit. So, this interaction leads to conceptual progress, though not about the topic we had intended.

However, during this interaction, the students blamed Zoe for the simulation going wrong. Jonathan, Devran, and Zoe all thought that the wrong settings had been chosen. Zoe apologizes to Devran and Jonathan. Jonathan accepts her apology, and Devran asks for her to just run the simulation again, with the correct settings. Eventually, they figure out that Zoe did not make an error, and they were able to have a productive conceptual discussion. However, we were concerned that the tutorial was unintentionally confusing and that the students blamed Zoe for that confusion. And we saw evidence that the use of the "ellipses" pre-set may have contributed to this dynamic, given Zoe's and Jonathan's mention of ellipses and the ellipses pre-set in line 12-13.

2. Zoe is left out of the discussion

Five minutes later, Zoe is setting up the computer to run a trial. The students were asked to predict how doubling the mass of planets (as compared to the previous setup) would impact the time they took to fall into the sun. While she is working on the simulation, Devran and Jonathan have a conceptual discussion about their prediction, based on the universal law of gravitation.

Transcript 2:

1	D	I know the formula for like planetary gravity or whatever. It's like M
2		one M two
3	J	Oh yea yea yea. I remember that from like high school.
4	D	That equals the force, (*Zoe looks at Devran*) So, there's a greater force if
5		both masses are increased.
6	J	(*Jonathan nods*)
7	D	which is weird, because it’s not intuitive and that doesn't really make
		sense.
8	J	so should it be faster? with a greater force. (*Jonathan turns his head*
9		*towards Devran*)
10	D	Yes? I guess?
11		(*Zoe moves her hand to the computer, starts setting up the next case*)
12	J	How much faster?
13	D	I'd say a hundred times. (*Devran moves forward, looks at his paper, then*
14		*starts to write his prediction on the paper*)
15	J	I think we have to check what the previous one before we do this. With
16		like the original one, because we don't know the time. (*Jonathan turns*
17		*his head towards Zoe, Zoe looks at Jonathan*)
18	Z	Yea. Imma do that after this one.
19	J	Okay
20	Z	Cause that will reset these bodies (*Zoe starts the simulation, Devran and*
21	Z	*Jonathan observe it*)

In line 1, Devran recalls a formula from his previous experiences. In line 8, Jonathan draws an inference from Devran’s recollection of the formula. He says, “So it would be faster? with greater force?” In line 12, he further refines Devran and his prediction by asking “How much faster?”

As observers, we noticed Jonathan and Devran try to make a prediction based on Devran's recollection of a formula from high school. In doing so, they engage in a conceptual conversation. However, Zoe appeared to be left out of the conversation and was instead adjusting the simulation; Devran and Jonathan called on her (line 16-17) only when they were ready to observe the simulation. So, she missed the chance to predict and engage with the universal law of gravitation. As observers, it looked like Zoe had been relegated to the role of computer controller, with no space for her to contribute to the conversations around the tutorials' questions. In making this point, we don't want to devalue the intellectual work she was doing. Throughout the tutorial, she translates the conceptual conversations and predictions into actions in the simulation. However, in the physics classroom, this work is less valued and frequently not translated into grades; she was much more likely to be tested, via paper-based problems, on the universal law of gravitation.

In summary, upon first watching those segments, we noticed Zoe getting temporarily blamed for a (non-existent) mistake in the simulation settings she controlled, followed by stretches of conversation in which she didn't verbally take part while she was adjusting the simulation (including the particular segment shown above). Because we had video of these interactions, however, we were able to take a closer second look, to confirm, disconfirm or refine our initial impressions.

In-depth analysis of data segments

1. The blame game

The following subsection includes an in-depth interaction analysis of the first transcript, now displayed with Waring’s Conversation Analysis Transcript Convention (Waring, 2015). These conventions are in Appendix C, which we recommend having next to the transcript while reading this.

1	Z	Alright, do I do this now?
2	J	Sure:: hit it.
3	D/J	((*Devran and Jonathan move from looking at their handouts to looking*
4		*up and facing the computer screen*))
5	Z	((*Starts to run the simulation*))
6	D	((*Devran leans forward*))
7		(2.5) ((*All three students look at the computer*))
8	D	Oh. Wow. ↓ Uhh=
9	J	hh
10	D	=completely wrong. ((*Devran smiles*)) They just all go into the sun,
11	Z	(2.0) .hh hh I really thought it was going to go around in a circle.
12		Hhhh ((*hearty laughter*)) I also thought thats what an ellipse was,=but I
12		guess?
13	J	Wow. (.) Wait, did we pick ellipse, (.4) {Is that [what that] ((*points at*
14		*computer screen*))}
15	Z	[↑Oh.] (1.) When did that happen? (.3) I really-
16	J	<$we just killed three bodies.$ °Three°>
17	Z	<$Oh no.$> ((*Zoe resets the simulation*)) (1.9)
18	D	( )-
19	Z	↑Ah. Why did I do that.=
20	J	=It's all good
21	Z	$↑Well$
22	D	°Just change {the velocity to zero.° ((*Devran sits up from the table, then*
23		*leans back into his chair*))}
24	J	((*Jonathan sits up and leans back at the same time as Devran*))
25	Z	°>Clearly Ive had a long day<° ((*resetting the simulation*))
26	J	hh ((*nods and sits forward*))
27		(2.0)
28	D	Actually, no wait, >thats what it was before.<
29	J	Hm. Change the-
30	Z	{-that's when we changed it to zero. ((*still using the computer to reset*
31		*the simulation*))}
32	D	Yea, we changed it to zero, thats whats gonna happen.

33	Z	((*Zoe resets the simulation to the default, nonzero ellipses*)) This is
34		what should happen ((*runs the simulation*)) (Computer shows the three
34		bodies orbiting the sun)
35	D	No, But see. That makes sense because there was initial velocity before.
36		There was, Um:: it's already moving in a direction, so the force is going
37		to influence it, but it's not going to go straight into the sun. But if you
38		put all velocities to zero then the=
39	Z	>Oh.<
40	D	=gravitational force on those masses- ((*Devran moves from facing*
41		*straight forward to turning and facing Jonathan*))
42		((*Jonathan and Zoe look at Devran while he is talking*))
43	J	{-Yea it's just going to collide ((*moves his left fist into his right palm*))}
44	D	=yea. it's just going to go [straight to it]
45	Z	[Oh, so] it was correct=
46	J	-Uhm:: (*Devran's gaze moves to Zoe, he does not turn his head)*
47	Z	=because it changed back
48	D	{((*Jonathan looks at Zoe*)) No, you} were right. We did it right the first
48		time.

Because Zoe controls the computer, it is she who asks if Jonathan and Devran if they are ready for her to start the simulation (line 1). Jonathan responds "Sure, hit it," indicating that he is paying attention and giving her the go-ahead.

Instead of seeing the planets orbit the sun, as the students expected, the planets fall towards the sun. All students were leaning forward and paying attention to the computer. For the first 2.5 seconds, the students silently observe what happens. Then, Devran starts audibly responding: "Oh, wow. Uhh" (line 8). He emphasizes the start of these words, suggesting genuine surprise. His pitch drops, which often indicates the speaker beginning to think something through. In line 10-11, Devran narrates the outcome they had just seen. He then inhales and laughs. He continues to say he thought the planets would go in a circle (line 11), echoing their prediction. Jonathan's reaction also indicates surprise: He reacts by audibly inhaling, and almost laughing.

Zoe responds to Devran by heartily laughing and expressing shock about the outcome (line 12). Responding to Devran's expectation, she states she thought an ellipse was something that went around in a circle (line 12), and she second-guesses her own knowledge base.

In line 13, after hearing "ellipses," Jonathan considered that the group may have made a mistake. He asks Zoe "wait, did we pick ellipse [as the pre-set]." At this moment, the "pre-set" box in the simulation no longer displays "*ellipses*." We infer that, since the outcome of running the simulation diverged far from what they expected and since the pre-set does not appear to be "ellipses," he thought there may have been a user error. Jonathan uses "we" when asking, nominally attributing the possible error to the group.

In line 19, however, Zoe says "Ah. Why did I do that?" She is using "I," as she was controlling the computer. In doing so, and in questioning what she did, she takes "credit" (really, blame) for not picking the right pre-set. Jonathan responds "it's all good," in line 20. He has latched on to what Zoe was saying, immediately saying that it was all right. Whatever the good intentions, the statement also acknowledges that it was Zoe's fault. In this way, Zoe, Jonathan, and Devran treat Zoe as having made an error setting up the simulation.

She then resets the simulation to rerun it. In line 22, Devran quietly says, "just change the velocities to zero," as he reclines away from the table. Prior to the perceived mistake, Jonathan and Devran did not micromanage Zoe's control of the computer.

As Zoe resets the simulation to the instructed setup, Devran realizes that the "new" setup matched what it had been before. In line 28, he quickly tells his groupmates, "that's what it was before." In line 30, Zoe uses the pronoun we to describe a change that she made to the computer. She groups herself with Devran and Jonathan, framing her actions as a group endeavor. In line 32, Devran echoes the use of the word "we", reiterating the collective identity of the group. Then, Zoe chooses the ellipses pre-set without changing the planet velocities to zero. The planets do indeed orbit the sun, which she states is "what should happen." In line 35, Devran explains that the tutorial's requested setup, with planet velocities set to zero, would lead to planets falling into the sun instead of orbiting, which occurs when the planets have initial velocities. After confirming that the planets should indeed collide with the sun when they have zero initial velocities, Zoe says "Oh, so it was correct" referring to the first setup of the simulation—the setup the group thought was erroneous. She does not explicitly give herself credit for being correct all along; she simply states that the first setup was right, and that no error was made. In line 48, Devran affirms that she was correct, saying "No you were right, we did it right the first time." Here, Devran tells her that she, as the person in control of the computer, was right. He also reaffirms the group's identity – that they had set up the computer correctly the first time.

In summary, although Devran and Jonathan end up acknowledging that Zoe did nothing wrong, for about a minute she was blamed for the perceived error. In that minute, Devran micromanages Zoe and she feels responsible for the alleged mistake. This, plausibly, reduced her credibility and agency in the group. These three students were able to figure out what went wrong and explicitly remove blame from Zoe, perhaps due in part to Zoe's running the simulation with non-zero planet velocities—which helped Devran focus on and make sense of the difference between the planets having non-zero vs. zero initial speeds. Still, we consider it problematic that she *was* blamed, for a few reasons. First, the unconscious emotional aftereffects of the blaming could linger into later interactions. Second, even if emotional aftereffects didn't linger in *this* group, we can easily imagine *another* group of students getting misled by the name of the *ellipses* pre-set, blaming the computer operator for messing up when they observe the planets *not* traveling in ellipses, and then failing to figure out their mistake or failing to explicitly “unblame” the computer operator. And as discussed below, we see the tutorial as contributing to this “blame” dynamic.

2. Zoe is left out: the importance of body language

Even though Jonathan and Devran absolved Zoe of blame, she is still left out of their later conversations. A deeper interaction analysis isn’t needed to confirm that she doesn’t speak until line 18 of transcript 2 above (section IV.A.2). So, instead of presenting a full interaction analysis, we supplement that verbal transcript with a closer

Figure 3.2. Zoe is on the left, leaning towards the bottom center of the figure, where the computer is. Devran is in the middle, casually leaning back in his chair. Jonathan, on the right, has also leaned back, as he and Devran predict how the next run of the simulation will compare to the previous run.

look at the students' physical placements and body language when Jonathan and Devran were having the conceptual conversation about the gravitational force.

When Devran recalled the gravitational force formula from high school (transcript 2, line 1), he leaned backwards, away from the table. Jonathan mirrored Devran's movement and also leaned back. Immediately afterwards, Zoe starts setting up the simulation for the next run. Because of the computer placement, she remained leaning forward. Figure 2 shows the positioning of the students.

Devran and Jonathan have both leaned backwards away from the table and their worksheets as they discuss what will happen. Zoe is unable to mirror their body language; she is leaning forward and appears occupied with setting up the simulation. Furthermore, Devran has his right arm crossed over his body, while his left arm is open. Zoe is on his right side and is, therefore physically blocked from the conversation—not literally, but in terms of the subtle messaging sent by body language. Her body language mirrors this block; her head is in her left hand, and she is focused on the computer. Zoe's forward lean cuts her off from the conceptual conversation. On Devran's other side, his left arm is back and is open towards Jonathan. As they talk, they make eye contact (not shown in Figure 3.2) and do not look at Zoe until asking her about the simulation.

In summary, the body positioning and body language during this interaction leave Zoe blocked out, mirroring the verbal conversation. From the interaction, it is unclear what combination of physical positioning, body language (likely unconscious), and Zoe's attention to the simulation makes it difficult for her to participate in the discussion. At the very least, however, it is likely that the physical positioning makes it harder for Zoe to enter the conversation than would be the case if the students were all facing each other with “open” body language.

Analytical takeaways

An inequitable dynamic arose between the students in the group. Specifically, Zoe, who presents as a Black woman, was asked to be in control of the computer by Jonathan, who presents an East Asian male. Zoe is blamed for a mistake she didn’t make, and then later, left out of the conceptual discussion.

We see a variety of factors, both systemic and local, which may have impacted the dynamic. As someone who presents as a Black woman, Zoe may carry multiple identities marginalized in physics and in American society more broadly. Presenting as Asian males, her group mates are marginalized in many American contexts, but less so in university physics. Since the clinical interview environment was clearly connected to physics and was not explicitly designed to disrupt these broader patterns of marginalization, the danger exists that the marginalization of African American women in physics could get (re)produced in this context (Carlone, 2004).

At a more local-interactional level, early in the interaction, Zoe takes the blame for something which was not her fault. Even if an emotional memory from this episode doesn’t unconsciously affect later interactions, Zoe’s role as computer operator may have been in tension with her taking on a greater role as co-discusser of the tutorial questions, for a combination of three reasons: The interaction may have constructed “computer operator” and “question discusser” as two disjoint roles; and/or, the spatial positioning and body language of the other students may have “blocked” Zoe from the conversation; and/or, Zoe's attention to the simulation may have made full attention to the conversation impossible.

Ironically, in previous research, computer controller emerged as a prestigious role with more power (Radermacher et al., 2014; Secules et al., 2018). This was not the case for Zoe. While in control of the computer, Zoe did valuable, but unseen work. This is the concrete, local-interactional sense in which we conceptualize the group dynamics as problematic and inequitable.

Based on our limited data, we cannot adequately address whether and how broader cultural narratives and power imbalances concerning women of color, and women of color in physics, affected these local interactions. Independent of the precise answer to this question, however, we consider it urgent to revise the tutorial to lessen the odds that such local-interactional inequities arise, because more equitable dynamics is an end in itself, because more equitable dynamics tend to lead to better problem-solving (Barron, 2003; Heller & Hollabaugh, 1992) and because some local-interactional inequities (re)produce broader systemic inequities in STEM (O'Connor et al., 2015; Secules et al., 2018).

Possible changes to the tutorial

In the previous section, we showed how the tutorial may have contributed to an emerging problematic group dynamic. Here, we outline some potential changes to the tutorial inspired by our analyses. These changes have not yet been implemented: like any potential tutorial revisions, they would need to be tested. Our point in this section is to illustrate how observations of group dynamics can inform potential revisions, motivating a research agenda to start testing when and how such revisions "work."

Changes to the use of the “ellipses” preset

One section of the tutorial told students to use the *ellipses* preset. We chose this preset because it assigns the planets equal but negligible mass compared to the sun, but different distances from the sun—exactly the desired scenario. Instead of prompting this preset, the tutorial could instruct students to set up a similar system by hand. This would take more time, but students would not be as primed to expect the planets to orbit the sun, and they would be reminded of the physical parameters. A downside to this approach, though, is that the computer operator’s attention would be occupied for even *more* time, potentially causing them to miss out on the conceptual discussion. Furthermore, if the students hadn’t expected the planets to orbit, they may not have figured out that non-zero initial velocity is what allows a planet to orbit instead of just falling into the sun.

Another potential fix would be to keep the *ellipses* pre-set but to just state in the tutorial that the planets will no longer orbit when their initial velocities are changed to zero. This would likely prevent or lessen the students’ expectation of (elliptical) orbits. But it would constrain the students’ predictions—helping focus students on how distance from the sun affects the gravitational force but failing to elicit what student might really think about this scenario.

The final potential change we brainstormed to mitigate the *ellipses* pre-set problem is to add a new tutorial section before the “problematic” one. In the new section, students would explore the effects of different initial velocities on the resulting orbits. Then, a question would ask the students to predict and test what happens when a planet’s velocity is removed (set to zero). This section would likely lay the groundwork for later sections which focus on circular and elliptical orbits, and it could prevent students from expectation an elliptical orbit, even in the *ellipses* pre-set, when the planet's initial velocity is zero. However, adding a section would take up limited class time.

Changes to impact the interactional dynamic

In addition to addressing the *ellipses* preset problem, we brainstormed ways to directly disrupt the dynamic by which Zoe, the computer controller, got left out of the conceptual discussions.

One approach is to include explicit instructions in the tutorial to switch computer operators every section or two. To the extent that controlling the computer distracts the user from the conceptual conversation, rotating who controls the computer would share that burden among all students.

Another potential modification would involve engaging the whole group, not just the computer operator, in figuring out the needed simulation settings. So, in in some question sequences, instead of the tutorial giving a detailed description of what the simulation setup should look like, the tutorial would ask something like "How can the simulation be set up to test the prediction you just made? Work together and come to consensus." A question like this would perhaps have made the tutorial setup an explicit conversation topic and could have pushed Jonathan and Devran to help Zoe instead of jumping ahead to the conceptual discussion without her.

Although this paper is about how tutorials could help prevent negative dynamics from arising, many factors are out of the tutorial's control. For example, Zoe was leaning forward, setting up the computer, while Devran and Jonathan were reclined away from the table, discussing the universal law of gravitation. She was not embodying the same physical space as they were. As tutorial developers, we can't address this directly, but we can add advice to the instructor's guide warning instructors to watch out for this body-positioning dynamic. The instructor's guide could include a more general suggestion to look out a student being left out of the conceptual discussion, with tips for preventing and mitigating this situation. So, we can use the instructor guide as a platform to communicate about the computer control issue and give tips on how to mitigate the negative dynamic. We can also ask instructors to make wireless keyboards and mice available, when possible.

To more directly take on the issue of marginalization and power imbalance in physics, the instructor's guide could suggest that instructors keep these systemic issues in mind when monitoring and intervening in group dynamics. All of our instructor's guides could suggest resources that researchers and activists have created to help facilitators create "safer" spaces for students historically marginalized in physics and STEM (*The Access Network*, n.d.).

Discussion

As shown above, a tutorial can contribute to negative team dynamics. We argued that tutorial authors can and should do what they can to minimize the tutorial's contribution to problematic team dynamics. This calls for careful observations of student groups working through the tutorial. In the process of making this argument, we also illustrated a small slice of the often- unseen process of tutorial revision. Specifically, we shared how we interpreted evidence of flaws in the tutorial and our brainstormed ideas, based largely on instructional intuitions, for potentially addressing those problems.

Pre-post testing, the most common form of tutorial assessment, will not reveal how teams of students work together on the tutorial. Our illustrative example details our process for coming up with potential refinements to our tutorial, to address group dynamics. Although the deeper analyses confirmed our initial impressions of how the group dynamics were going astray and added more nuance, our first-pass observations turned out to be sufficient to spot the *ellipses* pre-set problem and the Zoe-left-out problem. These kinds of first-pass observations don't require videotaping or even detailed field-noting.

Indeed, we believe that tutorial authors notice these kinds of problematic group dynamics as they observe the tutorial in real time. Furthermore, we believe that sometimes, they make tutorial revisions based on these observations. However, these observations and associated changes are not included in research articles about the tutorials. Tutorial authors rely on their instructional intuitions, but this process is hidden from view in journal articles. We are advocating for more *transparency* around these sorts of changes to tutorials. Such transparency can be generative for other curriculum developers when they're building on each other's ideas for question types, sequencing decisions, and so on; instead of relying solely on the finished product (i.e., the revised tutorial itself), those other curriculum developers could also rely on the observations and instructional intuitions underlying the finished product. Such transparency could also be helpful to instructors implementing the tutorial. By understanding *why* questions are worded and sequenced in certain ways, the instructor can facilitate student discussions in ways that cohere with the tutorial's design and can make more informed decisions about when and how to *change* the tutorial (Scherr & Elby, 2007). For example, if tutorial authors describe how observations impacted the flow of the tutorial, an instructor could understand how previous and upcoming sections of a tutorial depend on one another. Finally, such transparency could help other researchers. Reading about how (even informal) observations led to tutorial revisions, researchers could get ideas for research studies about how particular types of wording and sequencing correlate with students' interaction dynamics and learning.

In summary, we are advocating that curriculum developers attend to more than just conceptual growth; curriculum developers should be aware of the kinds of conversations that their tutorials afford and the learning benefits that it brings beyond cognitive gains. Transparency around these sorts of tutorial revisions would benefit instructors. While we do not think that a detailed description of every change the authors made to the tutorial would be helpful for instructors who wish to implement the curriculum, we believe that some insight into design decisions could benefit instructors, other curriculum developers, and researchers.

Conclusion

In this paper, we call for tutorial authors to attend to the tutorial's impact on interactional dynamics among students and to be more transparent as they report on the changes they make to the tutorial. The tutorial is one element of a system that sometimes produces inequitable group dynamics. The tutorial can be tested and revised to minimize its contribution to these inequities. In this paper, we show how observing the tutorial led to the identification of inequitable team dynamics and ultimately potential modifications to the tutorial. Tutorial authors regularly observe and tweak their tutorials on the basis of such observations. However, tutorial authors do not typically report these changes in research papers. And even in (rare?) cases when problematic team dynamics do not hinder conceptual growth, equitable dynamics are still important to the health of a physics classroom. Better interactions are important for their own sake. We want the physics classroom to be a humane place. Therefore, tutorials should promote more humane experiences.

Chapter 4: Using Role-plays to "see" inequities in mundane interactions in introductory engineering education spaces

Introduction

The Colorado Learning Assistant (LA) program was developed to transform undergraduate physics courses into more student-centric spaces, while equipping undergraduate physics students with the skills to be teachers (Otero et al., 2010). Over the past decade, learning assistant programs have extended beyond physics to other disciplines, including engineering. Each discipline includes its own instructional challenges that educators navigate.

In typical engineering design courses, students work in teams to develop products over the course of the semester. During this teamwork, unproductive team dynamics which perpetuate inequities can emerge (Tonso, 2006). Some instructional efforts aim to help students—or equally importantly, the instructors who teach the students—increase their awareness of unproductive group dynamics and take action to mitigate this harm.

In our engineering learning assistant program, the learning assistants are engaged in two spaces: (1) they serve as undergraduate teaching assistants in a first-year, engineering design course, and (2) they take a pedagogy seminar designed to help the LAs learn about engineering design thinking, equity, and engineering pedagogy. Many lessons in the LA pedagogy seminar focus specifically on how LAs can diagnose and help with teamwork troubles. In this chapter, I investigate a role-play—a semi-improvised performance guided by a prompt—which took place in one of these teamwork-oriented lessons. In the role-play and follow-up discussion below, the learning assistants wrestle with social-technical tensions, but ultimately use technocratic reasoning to justify cutting a student out of his work on their project.

In the rest of this chapter, I first use previous literature to motivate why I chose to investigate how engineering education culture emerges in a learning assistants' role-play. I present a portion of a post-role-play discussion where the learning assistants navigate social and technical tensions which occurred during the role-play. Using interaction analysis, I examine how harmful engineering ideologies underlie their reasoning and approach to solving the issues presented in the role-play.

Literature review

Role-plays and rehearsals for teaching training

Rehearsals have been used to help novice teachers develop "ambitious mathematics teaching" practices (Lampert et al., 2010). One strategy that Lampert et al. developed is rehearsals (Lampert et al., 2013), which involve novices publicly and deliberately practicing how to teach rigorous content to students using instructional activities. They investigated how interjections and exchanges between novice teachers and teacher educators during the rehearsals by looking at the substance and structure of the interaction between the teacher educators and novice teachers. Rehearsals allow novice teachers to retry, reconsider, and receive targeted feedback. Research on rehearsals has generally been focused on promoting ambitious math teaching and responding to students' ideas (Averill et al., 2016; Ghousseini, 2017; Kazemi et al., 2016; Lampert et al., 2013; Wæge & Fauskanger, 2020). Furthermore, many studies investigated using timeouts and coaching questions during the role-plays (Averill et al., 2016; Wæge & Fauskanger, 2020).

For example, Kazemi (2016) studied how to support novice teacher's learning from rehearsals, where learning equates to become better at enacting ambitious mathematics teaching practices. Her research established, among other things, the importance of the authenticity of the rehearsals to those novice teacher’s classroom experiences, and the importance of a classroom culture in making rehearsals safe. Ghousseini (2017) looked at how rehearsal tasks support pre-service teachers in developing mathematical knowledge for teaching, such as eliciting mathematical representation from their students. Averill (2016) investigated how in-the-moment coaching questions during rehearsals helped pre-service teachers promote ambitious mathematical thinking and can inform and empower novice teachers in equitable and ambitious mathematics teaching. Wæge and Fauskanger (2020) examined in-service elementary teachers in Norway use of rehearsals to learn about ambitious mathematics teaching together, in a scaffolded way. They found that rehearsals were a valuable approximation of practice, where the in-service teachers could develop their ambitious teaching.

There are some exceptions to this pattern. As a part of a two-year ethnographic study on a teacher community of practice, Horn (2010) found that rehearsals, where teachers narrate or act out classroom interaction in an imagined or anticipatory fashion, supported teachers in reframing their understandings of complex teaching situations with other teachers in their community. The teachers in the community of practice would often "re-vision" or reframe events which occurred, signaling teachers' learning from their colleagues. Baldinger and Munson (2020) investigated debrief discussions following rehearsals during a professional development early-career secondary mathematics teachers, which focused on non-rehearsing teachers (who played students during the rehearsals). They found that the debriefs provided opportunities for non-rehearsing teachers to share their experiences as "students," develop "adaptive expertise," and consider the implications for teaching.

The engineering learning assistant research team, of which I was a part of, designed, implemented, and studied role-plays in the pedagogy seminar. These role-plays build off Horn (2010) and Baldinger and Munson's (2020) work. These role-plays were designed to highlight the complex dynamics educators face when helping students navigate teamwork troubles, including tensions that arise at the intersection of technical and social issues. The role-plays were often based off of situations that the LAs brought forward. Tanu et al. (2017) investigated how a learning assistant utilized empathy to navigate a tension between productive student learning and student emotion. The LA in this study drew on their empathy to develop new instructional moves. In previous work (H. Sabo et al., 2019), I found that learning assistants can develop deep embodied knowledge of power dynamics and emotions embedded in interactions, partly by making visible the coupling of linguistic, metalinguistic, and emotional qualities in those interactions. Furthermore, I found that learning assistants who played students could draw on their insights as recipients of the teaching moves, aligned with Baldinger and Munson's (2020) work.

I chose to study role-plays because of the various documented educational benefits, but until my research on role-play studies, little or no work has explored whether one of those benefits is helping students "see" and challenge problematic aspects of STEM/engineering education culture, such as technocratic norms—particularly in the context of instructional decision-making around teamwork troubles.

Engineering (education) culture

Scholars have documented harmful ideologies, such as meritocracy, technocracy, and the social-technical divide, which permeate engineering and engineering education culture.

In *Engineering and Social Justice,* Riley (2008) analyzed and documented mindsets in engineering culture. These mindsets include (1) a commitment to problem solving, (2) narrow technical focus, and (3) positivism and myths of objectivity. Given these mindsets, engineering is seen as a domain where technical knowledge is used to find the best solutions to problems (despite that design-thinking largely considers trade-offs). In a similar vein, Erin Cech describes ideological pillars of engineering, "the ideology of depoliticization, which frames any ''non-technical'' concerns such as public welfare as irrelevant to ''real'' engineering work; the technical/social dualism, which devalues ''social'' competencies such as those related to public welfare; and the meritocratic ideology, which frames existing social structures as fair and just" (Cech, 2014, p. 45). She found that as engineering students progress through schooling, they became less concerned with public welfare.

The socio-technical divide is a false dichotomy evident in engineering culture and reproduced in engineers' thinking, which separates technical work and competencies from social competencies. Faulkner describes social-technical dualism as "the distinction between being technology-focused, on the one hand, and people-focused, on the other” which is “manifest in the distinction often drawn between narrowly specialist and more holistically heterogeneous types of work and knowledge in engineering” (Faulkner, 2000, pp. 761–762).

Often, accompanying the social-technical divide—the separation between technical and social issues—is technocratic ideology, the valuing of the technical over social skills and competencies. For a range of reasons, in both the engineering workplace and in engineering education, this narrow technical focus results in exclusion of underrepresented minorities from engineering (Cech, 2014; Riley, 2008; Slaton, 2015). In Rigor/us, Donna Riley (2017) describes how the concept of academic rigor produces and maintains inequities in the field of engineering education research. Rigor is used to draw boundaries and upholds a narrow definition of successful engineering work. In place of rigor, Riley proposes the idea of "vigor" to increase inclusive engagement in engineering education spaces.

Another ideology identified by Cech are meritocratic beliefs, that people are rewarded based on their ability and hard work, use narrow definitions of what counts as ability and work to sustain the current systems of power. Society, as a whole, is not critical of meritocratic beliefs and unchanging presumptions of what is "good engineering" that continues to exclude certain communities from engineering. Under meritocracy, current systems prevail; the citizen must learn to work in ways that align with the current definitions of valuable knowledge and labor, rather than think innovatively or expansively (Slaton, 2015).

In addition to heavily influence American engineering culture, meritocratic and technocratic ideologies are also reproduced in engineering education spaces.

O’Connor, Peck, and Cafarella (2015) investigated how the classification "math readiness" and grades shaped engineering students' activity and trajectories within a diversity program. They present a case study on how one student struggled for legitimacy in the program due to their math preparation, even though the student had a patent and a business for an invention he made. Students become naturalized in engineering through taking courses and grading, rather than looking at their activity as engineers. This reflects a meritocratic, narrow definition of success, where students merit their identity as an engineer based on their grades, rather than looking holistically at their activity broadly.

Although studies of engineering (education) culture are common, few investigate how these ideologies manifest as inequities in moment-to-moment interactions. Tonso (2006) draws on ethnographic methods to describe how engineers practice design teamwork, showing that, in the campus’s engineering culture, certain celebrated roles on design teams were largely inaccessible to students based on gender and sorority/fraternity membership. Faulkner (Faulkner, 2007) also draws on ethnographic methods to describe how, in an engineering workplace, masculinity and “technicist” identities became entangled, constraining the identities available to both women and men. These studies show how meritocracy and a narrow, technical definition of success combine to create technocratic, exclusionary engineering education spaces. My work differs from these other cultural studies by focusing not on students or working professionals but on peer educators, specifically learning assistants.

This research project has broadly examined how learning assistants sense-made around and responded to teamwork and equity issues within undergraduate engineering design teams by investigating learning assistants' writing on teamwork issues and reflections on readings (Turpen et al., 2018). This research team has also examined how engineering learning assistants reproduce and challenge these harmful ideologies (Turpen et al., 2019).

These aspects of engineering culture shape the ways in which resources and status are distributed within teams and organizations. This influence extends beyond engineering culture, into engineering education culture. Since the learning assistants are placed in a first-year engineering course, they have the ability to shape their students' trajectories and beliefs about engineering. In this chapter, I investigate how the social-technical divide and technocracy underlie learning assistants' moment-to-moment reasoning and framing around a role-play scenario and how those ideologies impact their instructional moves.

Methods

Settings & context

The undergraduate teaching fellows were in a learning assistant program which follows the CU Boulder LA Model (Otero et al., 2010). The learning assistants concurrently enroll in a 3-credit pedagogy seminar and spend approximately ten hours a week supporting first-year students in an introductory engineering design course. The students in that course work in teams of eight to design and build an Over-Sand-

Vehicles (OSVs) which navigates a small arena and accomplished a certain "mission," such as testing the PH of a liquid. Each LA was placed into a section with 40 students.

In addition to working in classrooms, the learning assistants enrolled in a 3-credit pedagogy seminar, designed to support LAs in cultivating engineering pedagogy, supporting design thinking, and equitable teamwork. See Quan et al. for a description of the 2016 iteration of the pedagogy seminar (Quan et al., 2017). Activities were designed to help LAs notice and respond to concrete teamwork troubles that arose in their sections, such as discussing successes and challenges of teaching, reading and discussing engineering education articles, role-playing specific interactions between LAs and design teams, writing descriptions of scenarios that arose in their students' teams, brainstorming instructional moves in response to those scenarios, and imagining students' reactions to those moves. This analysis focuses on one of the role-plays which occurred during the ninth week of the 2018 iteration of the seminar.

The pedagogy seminar, which met for two and a half hours a week for a semester, was audio- and video-recorded. Additionally, field notes were taken and artifacts such as student responses and activity handouts were collected. From the field notes, the four places where role-plays occurred were identified. After the role-play and discussion were selected, the second run-through of the role-play and the whole-class discussion were transcribed.

Role-play selection

This dissertation chapter focuses on a discussion following one of the four role-plays which occurred in the 2018 iteration of the pedagogy seminar. In this discussion, the LAs recruit the sociotechnical divide, technocracy, and empathy as they articulate their prioritization of solving the role-play's group work issues. One of the goals of this pedagogy seminar is to support learning assistants in developing technical and social solutions in concert, bridging the sociotechnical divide, rather than as separately stratified. The research arm of this project aims to see the effects of the pedagogy seminar on the learning assistants. This data was selected for analysis because the learning assistants try out social solutions, but ultimately fall back on technocratic reasoning during the post-role-play discussion and to better understand the dynamic in order to design learning environments to disrupt this technocratic reasoning.

In this chapter, I examine the first ten minutes of the post-role-play debrief because the learning assistants clarify and sense-make around the role-play scenario. As they gather more information, their framing of the scenario changes. In this chapter, I discuss the first ten minutes of the discussion, where the learning assistants discuss the social and technical issue in the role-play.

The role-play scenario

In this section, I describe the role-play scenario and the events that occur during the two iterations of the role-play. Because learning assistants are in a role where they are both students in a pedagogy seminar and on an instructional team, the language can be confusing. For the remainder of this paper, I will use the term *student* to refer exclusively to the role-play characters who are students. The term *instructor* will refer to those who "acted" as instructors during the role-play. The term *learning assistant* or *LA* will refer to the learning assistants during the whole-class discussion.

In this section, I describe the role-play scenario and the events which occur during the two role-play iterations. The LAs were given information sheets that contained some elements of the students' personalities and broadly described the troubles that the students were facing. The rest was improvised by the LAs who played students, who drew on their own ENES100 and LA experiences. The focal role-play scenario was repeated twice with two groups of instructors and the same group of students in both iterations. After the role-play, the whole class engaged in a discussion.

The scenario involved a fictional group's teamwork troubles, containing two intertwined issues: (1) a technical "circuits" issue, and (2) a group-attendance issue. A table containing each character's traits and responsibilities is displayed below in table 4.1 and a copy of the role-play prompt is attached in appendix D.

Abe, Bee, and Colin comprise the group's mission team, in charge of assembling the OSV (attaching equipment, like wheels to the chassis) and completing the mission. At this stage, they are in charge of building the chassis of their OSV. Mike, who is in charge of the electronics (circuits), is out sick that day. Their teammate in charge of the programming, Kal, seems to get his work done, but is absent and does not frequently communicate with the rest of his team.

Earlier in the class, the instructors noticed Abe, Bee, and Colin sitting around, not working. The instructors asked them to "find something to do" (appendix D). Thirty minutes later, Abe, Bee, and Colin return to the instructors with a question about the circuit that Mike drew. They're trying to understand how to wire the motors so that each gets the voltage that they need and the battery life is maximized. The role-play begins with Colin explaining the technical problem.

Description of the role-play

Role	Character	Played by
Abe, **student**	Abe is on the mission team. He has a history of absences earlier in the semester but has been attending class regularly since. His classmates harbor resentment towards him.	Stephen
Colin, **student**	Colin is on the mission team. He is nervous about the direction of the OSV and upcoming deadlines for the OSV. Colin and Bee are friends and are mean to Abe.	Quinn
Bee, **student**	Bee is on the mission team. Friends with Colin. Less nervous, but still exclusionary towards Abe.	Parker
Instructors 1st Round: Kurt, Theo 2nd Round; Tony, Nora, Lexi,	themselves Note: One of the learning assistants, Charlotte, was not present in the seminar on this day.	Kurt, Theo, Tony, Nora, Lex
Mike	Mike oversees the OSV's electronics. He created the circuit schematic, which Abe, Colin, and Bee try to implement. He is out sick but has no history of absences.	Mentioned in the role-play prompt and context, but not portrayed by any LA.
Kal	Kal works on the OSV's programming. He is frequently absent and does not regularly communicate with the team. However, he "gets his work done."	Mentioned in the role-play prompt and context, but not portrayed by any LA.

Table 4.1 A table containing the role-play actors and their roles

Both iterations of the role-play started with Abe, Bee, and Colin explaining their question to the learning assistants and Quinn, who plays "worried Colin," improvises a deadline that is making his character anxious. In the first iteration, Kurt and Theo spend their time helping the students with their OSV. In the second iteration, Tony, Nora, and Lexi start out by addressing the attendance issue that the team is facing. Both sets of learning assistants find out that Mike, the electronics worker, is out sick and Kal, the programmer, regularly ditches class but his work gets done. After the second run-through of the role-play, the class discussed the issues from the role-play; this discussion is analyzed below. A full transcript of the second run through and the whole class debrief is include in appendix E.

Analysis

I draw on tools from discourse analysis and attend to the substance of the learning assistants' utterances during the role-play debrief. In this chapter, I look at how the learning assistants defined and navigated the tensions in the role-play scenario. Framing, a tool of interaction analysis, investigates how situations are defined by participants (Goffman, 1974; Goodwin, 2007; Tannen, 1993). In this work, I make two methodological assumptions. First, it is worthwhile to examine what students say to better understand students' experiences, thinking, and the effectiveness of learning environments. Second, students' reasoning is dynamic and context dependent. As the learning assistants reflect on the role-plays during the whole class discussion, the nuances of the role-play scenario are clarified. As new information emerges, the learning assistants' framing of the problems and the prioritization of solving those problems shifts.

I developed an analysis chart to examine the learning assistant's utterances. An example chart row can be seen in figure 4.1. On the far left of the chart, I summarized what occurred during the speech. Next to that summary, I included the full utterances.

If the utterance was longer, the row contained just the one statement. If there were several quick utterances (less than one typed line), they were analyzed together. I examined each utterance to look at how the learning assistant (or instructor) interpreted and framed tensions in the role-play scenarios. I also examined who the learning assistants responded to and how new information and reflection caused shifts and stabilities in how the learning assistants interpreted the role-play problem. Additionally, I looked at how common ideologies in engineering and education, such as the sociotechnical divide, technocracy, impacted how the learning assistants framed and interpreted the role-play scenario and which characters the learning assistants had empathy for. I investigated how those ideologies develop throughout the first ten minutes of the discussion.

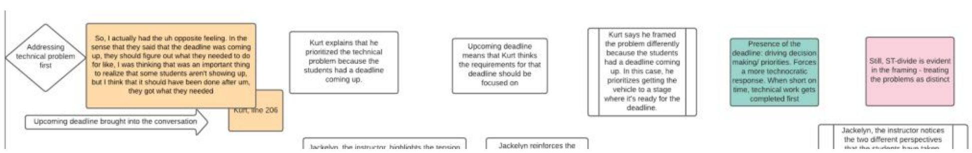


Figure 4.1 Example analysis chart row. Here, Kurt talks about why he addressed the technical problem first. He reminds the learning assistants about the upcoming deadline and cites that as his reasoning for addressing the technical problem first. I describe how Kurt frames the role-play scenario and his proposed solution. Finally, I describe how technocracy and the social-technical divide underlie his reasoning.

In this chapter, I closely look at the LAs' utterances during the first ten minutes of the conversation. I look at how the LAs frame the problem(s) in their speech and how reflection on the scenario shifts the LAs' understanding and prioritization of the problems. Further, I investigate how the LAs recruit technocracy, the sociotechnical divide, and empathy give precedence to solving the issues.

Analysis & findings

In this chapter, I analyze the first ten minutes of the role-play debrief. As the LAs reflect on the role-play prompt, more nuances from the context and the problem emerge. As the learning assistants reflect on the role-play, their framing of the problem changes. For example, during the role-play, the instructors worked with the team to solve the social solution before addressing the technical problem. I divide this narrative into two acts, shown in figure 4.2. At the start of the full class discussion, one of the learning assistants calls the social problem "the more important issue." However, when another learning assistant uses the deadline as a justification for elevating the technical problem, the first LA changes his mind and agrees that the technical problem is more important. When the learning assistants are asked to empathize with an absent student whose work was changed, the learning assistants resist, stating the prominence of the deadline and his lack of technical correctness. While they appeared to make some progress on intervening at a social level at first, the LAs eventually defaulted to the technical solution.

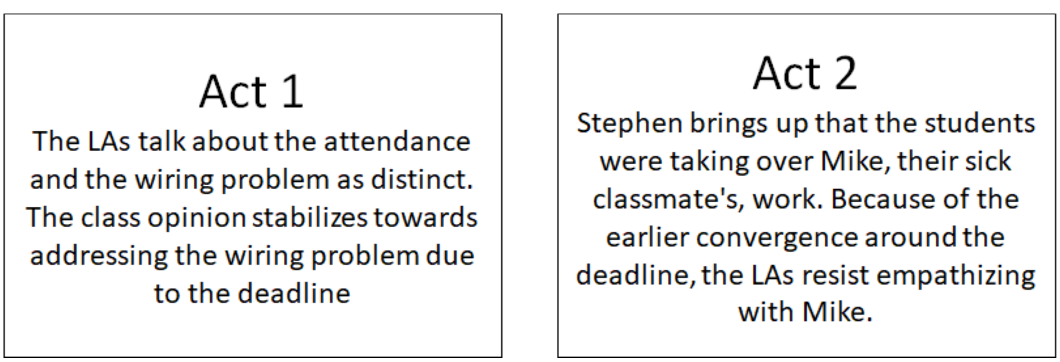


Figure 4.2 A description of the two acts which comprise the analysis.

Act 1: A tale of two problems

After the second role-play ended, Jackelyn the instructor asked the learning assistants what they noticed during the role-plays. The LAs describe two different problems: one involving the missing teammates and another involving the circuits problem. In this first section, they talk about how they prioritize solving those problems, based on the information during the role-play and from the handout sheet.

Tony was the only second-year learning assistant in the seminar; because of his experience, the other learning assistants gave him a lot of credibility and influence in the seminar. He responds to Jackelyn,

> *"I think the first time around, they didn't talk about the students not- address what I think was a bigger problem- that the students weren't showing up to class. Um, cause they just said that Mike and whoever the other guy was (Quinn: Kal) just weren't there. So, that should be like an immediate bell of a problem before you dive into the circuit mess" (Tony, lines 202, 204).*

At the beginning of the discussion, Tony describes two problems that emerge during the role-play, a circuits problem and an attendance problem. In his framing of the problem, he treats them as two distinct problems to be resolved, rather than consider how they may be interconnected. He calls the attendance issue "the bigger problem," elevating it over the circuits problem that the students had brought to the instructors. Tony is the only returning learning assistant in the course. Tony and the other learning assistants often positioned him as an expert. As an "expert," he critiques the first group for not talking about where the missing classmates were. It was unusual for Tony to prioritize social solutions over technical problems; Tony typically values technical work above social dynamics. In his response to Jackelyn's question, he uses absolute language, calling the attendance problem "the bigger issue." Kurt, who was an instructor in the first run-through of the role-play, responds to Tony by explaining why he prioritized solving the circuits problem. He says

> *"So, I actually had the uh opposite feeling. In the sense that they said that the deadline was coming up, they should figure out what they needed to do for like, I was thinking that was an important thing to realize that some students aren't showing up, but I think that it should have been done after um, they got what they needed" (Kurt, line 206).*

Kurt explains that he treated the role-play scenario differently because of the deadline that the students had coming up. To him, the upcoming deadline meant helping the team meet the requirements for that milestone. Kurt takes up Tony's conceptualization of the problems as two separate problems to be solved. He reminds the class of the deadline and explains his reasoning for the prioritization of the two issues - if they are short on time, Kurt values preparing the students for their upcoming deadline.

Jackelyn, the instructor notices the two different perspectives offered by the learning assistants. She opens this discussion up to the class by asking how they navigate those tensions. In echoing her students' ideas, she reinforces the separation between the circuits issue and the attendance issue.

> *"Alright, so there's an interesting then um decision to be made. Which do you address first? Do you address the technical issue of their batteries, or do you address teamwork issues? Any thoughts on that? Since the two groups did it very differently. And perhaps what the students who chime in if you wish." (Jackelyn, line 208)*

Jackelyn, the instructor, highlights the tension that the LAs have articulated. They perceive there to be two problems the students are facing: (1) some of their teammates are missing class, and (2) there is a circuits problem on their over-sand vehicle. The LAs articulate the two problems and Jackelyn echoes these problems back to the LAs. In Jackelyn's move here, as an instructor, she brings the rest of the class into the discussion. She invites the other learning assistants to share how they would prioritize solving the two competing issues. Jackelyn reinforces the divide between the two problems by asking the students which of these two problems the students would address first; she reifies the distinction between the two problems.

After the deadline is mentioned, Tony's framing around prioritizing the attendance problem destabilizes. He responds by reasoning why he had not prioritized the deadline–it was not mentioned on the sheet.

> *"I mean there's nothing about um a deadline coming up on the sheet, so that's why we started off with that. And then when they said "We have a deadline coming up, we diverted to the circuit problem." (Tony, line 209)*

Tony does not orient to Jackelyn's move to open the discussion to the rest of the class. He responds to what Kurt said the line before. He ignores what Jackelyn has said about how they go about prioritizing the two issues. Tony ignores Jackelyn's "rights" and power as instructor of the class to open up the discussion to the rest of the class. Without inscribing sexist intent to Tony, I note that this dynamic replicates societal sexist patterns where women's remarks are sometimes ignored, while males continue conversation, even though Jackelyn has power as the course instructor. He starts defending why he prioritized the attendance issue over the technical. It was unusual for Tony to elevate a social problem over the technical problem. After hearing Kurt talk about the deadline, Tony starts to get defensive. He is concerned about focusing on an attendance issue when there is an upcoming deadline that the students are not prepared for, so he blames the students' improvisation for his overlooking of the deadline. Although he just called the attendance issue "more important" seven lines before, he says that they told the students to work on the circuits problem as soon as the students said they had a deadline coming up. Upon discussing the deadline, Tony's framing of the attendance problem as more important destabilizes. He responds by reasoning about why he did not prioritize the deadline initially. The LAs who played students in the role-play respond to Tony's question about where the deadline came from.

> *"So, it wasn't an issue on our sheet" (Quinn, line 210)*
>
> *"Yeah, you just made it up" (Tony, line 211)*
>
> *"My role was, I think my role was that I was just supposed to be worried. So, I was like" (Quinn, line 212)*
>
> *(Parker laughs) (line 213)*
>
> *"I just gave my team members" (Quinn, line 214)*
>
> *"We've got a deadline coming up in six weeks." (Stephen, line 215)*

Quinn played the student, Colin, who is "worried about where things are going" (see role-play scenario handout in appendix D) that the team has made so far. Quinn interprets this worry as a student who is constantly concerned about deadlines, no matter how far out. The engineering design course has unmovable deadlines, which tend to be anxiety-inducing for students. Quinn captures this anxiety in his characterization of Colin's worry. Tony again points out that the students improvised the deadline, justifying his explanation for why he prioritized the attendance issue over the technical. Rather than use the word "improvised," he says "yeah, you just made it up," suggesting that it was unexpected and not based in the role-play, again showing defensiveness for why he missed it initially. As the LAs talk about the origin of the deadline, Quinn talks about how his worried character is one who is concerned about deadlines.

Lexi reflects on how she felt that intervening on the attendance issue was unsatisfying. She perceives the social issue as difficult to find a solution to.

"I felt like it was kind of unsatisfying for the first and second round. We tried to talk about the attendance issue more for the second round. But we still didn't really come to like a good conclusion (Jackelyn: About how to handle the attendance issue?) Yeah, we definitely like brought it up more. But we still didn't really like, come to anything else to do besides like, because [the students] said they had already talked to [their absent classmates]. And we didn't really have any other advice besides like talk to them more." (Lexi, 218-220)

Lexi perceives the social situation as difficult to find resolution for. She says they didn't come to a good conclusion, which she found "unsatisfying." Her description reinforces the perception that social problems are messier and less clear to solve than technical issues, echoing the sociotechnical divide. Engineering design problems are about figuring out the problem spaces and weighing the tensions, yet the LAs perceive the technical issue as straightforward and the social issue as more complex.

After Lexi shares, Tony converges towards favoring intervening on the technical solution over the attendance problem. He shares his stance with the class.

"I think in both cases, parsing the fact that Quinn just made up the deadline. But like if there wasn't a deadline, we could have spent more time on it but, it is more important because there is a deadline, that is the more pressing matter" (Tony, line 221)

Tony's framing of the problem and its solutions explicitly shifts here. Tony weighs the circumstance of the deadline into his consideration of the problem. Tony says that if there was not a deadline, then they could have spent more time talking through the attendance issue. The instructors interpreted the deadline as immediate. With the deadline fast approaching, he feels pressure to equip the students with "what they need," in this case, technical help. The deadline took away time from the discussion of the attendance and communication issues. Tony recruits technocracy in his reasoning here; when there is a time crunch, the technical problem takes precedence over the missing students and team communication. Tony's prioritization of the issues changes when the resource of time is limited.

In the first part of the discussion, the LAs discuss the main tension that they found during the role-play, there are two competing issues. As they talk through how they went about solving these tensions, the LAs shift more towards addressing the circuits problem over the attendance problem, given the presence of the deadline. In this portion of the discussion, the LAs do not consider how the two problems might be fundamentally related - they see the issues as distinct from one another.

Act 2: Empathy & resistance

In the second part of the discussion, one of LAs who played a student, Stephen, draws attention to a facet of the role-play scenario which the instructors had missed - the students had taken over their sick classmate, Mike's, work when their own job was not yet complete. This information changes how the learning assistants define the two problems and allows the LAs to connect the attendance problem to the circuits problem. Jackelyn asks the class what they think will happen when Mike returns to class. However, due to a technical error in Mike's earlier work, the LAs refuse to empathize with Mike.

Stephen starts to share an idea with the class but gets cut off; Jackelyn asks the class to listen to what Stephen has to say.

I think that you guys- (Stephen, line 223)

May I ask you to let Abe talk (Jackelyn, line 224)

During the role-play, Stephen played Abe, whose teammates frequently talked over him because of his previous lack of attendance. As Stephen starts to bring up a point during the discussion, he is cut off by his classmates. Jackelyn uses her positioning as instructor to make space for Stephen to share his insight. In doing this, she references the role-play, highlighting a connection, that they were both talked over and ignored, between Abe and Stephen. Jackelyn uses her positioning as instructor to make space for Stephen to share his insight with the rest of the class.

After Jackelyn ensured Stephen had the space, Stephen shares information that he thought the learning assistants in both iterations of the role-play had overlooked.

> *"I think that something was that was sort of missed was that we were working on electronics at all. Cause like supposedly, the instructors told us to just do something and we chose to do electronics even though we're the mission team. So, like" (Stephen, line 225)*
>
> *"We *indistinguishable*" (Quinn, line 226)*
>
> *"Yeah, it's not done" (Parker, line 227)*
>
> *"The chassis is barely complete. We have to like build in all of the mission completion stuff." (Stephen, line 228)*
>
> *"wait, the chassis not completed?" (Kurt, line 229)*
>
> *"No, like the wires and the tires aren't on or anything" (Parker, line 230)*
>
> *"There's no wheels and no mission specific things." (Stephen, line 231)*
>
> *"So, going along with that" (Jackelyn, line 232)*
>
> *"That's a good point" (Tony, line 233)*

Stephen, who played a student, points out that the students had taken over their sick classmate's electronics work. The other students, Parker and Quinn, agree with Stephen and add that the basic mission-related features of their OSV still is not complete. Kurt and Tony respond with surprise; as they made their decisions about what problems to prioritize, they had not considered that the OSV was missing mission-related equipment. Although the learning assistants had previously converged around addressing the circuits problem given the deadline, this new information surprises the learning assistants and has potential to destabilize their prior convergence.

Jackelyn responds to Stephen's comment by shifting the direction of the discussion. Rather than asking for their prioritization of issues, Jackelyn invites the students to consider the impacts of their instructional moves when Mike returns to class.

> *"One of the thoughts that I had was um, so what if, so Mike is, in theory, been working on some of these things. What do you think would happen when Mike comes back the next class. If you guys have started implementing these changes" (Jackelyn, line 234)*

Jackelyn makes a bid for the class to consider how Mike might feel and what might happen in the group when Mike returns to class and realizes that his work has been changed. She asks the learning assistants to empathize with Mike and the group, and to consider how he might react to his work being changed in his absence.

Jackelyn's bid to consider what might happen in the next class is met with pushback from the learning assistants.

> *"I mean, he thought series [circuit] would increase the battery life, which is a major issue" (Stephen, line 235)*

> *"Yeah" (Tony, line 236)*

Despite the fact that Stephen brought up that they had taken over Mike's work, Stephen rejects Jackelyn's bid to consider what might happen when Mike returns. Rather, he cites Mike's technical error as a reason not to give weight to how Mike might feel when he returns. Tony agrees with Stephen and also refuses to engage with Jackelyn's bid.

Although there is initial pushback, Jackelyn restates her bid. She acknowledges that Mike may be technically wrong but does not let that invalidate her question.

> *"Okay, so if he's wrong, I'm wondering still what will that interaction be like? What can you imagine about that interaction when he comes back and now things have been changed? Whether he was, it seems like he was wrong" (Jackelyn, line 237)*

Despite the initial pushback, Jackelyn repeats her question, asking the learning assistants to consider it. In particular, she says "I'm wondering *still,*" suggesting that, despite Mike's incorrectness, she would like the LAs to consider what might happen when he returns. She reiterates her bid for the LAs to empathize with Mike and the team - and to envision how their instructional moves might impact the team when Mike returns.

Jackelyn takes Stephen's observation and adds a more directed question to that observation. She invites the class to consider what might happen because of their instructional moves. The LAs position Mike (the absent student) as "wrong" and initially refuse to consider how Mike might feel. Jackelyn reiterates her bid - to consider what might happen when the students return to class, even if Mike had an error in his work. At this point, the learning assistants start to think about how Mike and his teammates might feel. Jackelyn utilizes her power as an instructor to not let the question be written off.

After Jackelyn repeats her question, Stephen starts responding to it; he suggests that Mike might lose some trust in the group because the mission team took over his work. However, as the LAs discuss, they quickly switch from thinking about how Mike might feel to how the group might feel about Mike.

“It seems like he'd be pretty untrusting of the group because” (Stephen, line 238)

“Untrusting? Okay” (Jackelyn, line 239)

“Yeah cause like when the mission team” (Stephen, line 240)

“Yeah, maybe like a loss of credibility in the work he's been doing.” (Quinn, line 241)

Stephen takes up Jackelyn’s bid; he suggests that Mike might be “untrusting” of the group because his teammates changed his work while he was out sick. He could not trust his group to not make changes to his work while he is absent. Quinn adds that he may feel a loss of credibility in the work that he’s been doing; he would feel that way because the group found an error in his work and took initiative to change it without consulting him. He might feel like he no longer had credibility or ownership over his assigned tasks. Stephen and Quinn start considering how Mike might feel when he returns to class.

However, the learning assistants quickly shift from empathizing with Mike to considering how his teammates might feel after finding an error in his work.

“Probably like you guys would be untrusting.” (Lexi, line 242)

“Yeah, like we would be untrusting of Mike.” (Quinn, line 243)

After hearing the word “untrusting” and combining it with a loss of credibility in Mike’s work, Lexi brings up that the present students may now be wary of Mike’s work. Because he made a technical error, the group may have less confidence in Mike’s future work. As the learning assistants consider what might happen when Mike returns to class, they start out considering Mike’s feelings. However, they quickly shift to considering how his teammates might feel about him instead. The LAs quickly shift to empathizing with the students who found the error, rather than the student who made the error.

Tony talks about how the instructors asked the students to inform Mike of the changes during the role-play and how those actions might impact the discussion when Mike returns to class.

> *"I mean Parker said she was going to, or Nora told Parker to text them about the changes. So, assuming that occurred, and Mike is a reasonable person, then I don't think he would get frustrated because he was wrong in that case. But if it was a design decision that they made without Mike being there, then that could result in some conflict. But because it's something that's mostly cut and dry and Nora instructed Parker to tell them, tell Mike of the changes and the fact that he talked to the TAs, then I don't think there'd be too much conflict, as it would be like, Mike would start untrusting his own teammates."*
> *(Tony, line 246)*

Tony reminds the class that Mike was theoretically informed of the changes, so at least he would not be shocked when he returned to class. Tony characterizes the circuits problem as "cut and dry," that there is a clear solution that can solve the circuits problem; the problem is characterized as having one solution. Because of the communication between the teammates and the characterization of the problem as having one solution, Tony suggests that if Mike were a "reasonable person" he would understand because his design was wrong. He characterizes a reasonable person as one who divorces their feelings from the technical progress of their mission. Since the changes were informed by discussion with the TAs, Tony thinks that if Mike were a "reasonable person" there would not be conflict when Mike returned to class because he would value the troubleshooting that his teammates had done. Tony constructs Mike as incorrect and a reasonable person, which invalidates any negative feelings that Mike might have around the situation because he had an error in his work. With the error in his work, Mike lost the right to care about changes made to the vehicle. Tony's positioning as an expert gives his words more weight. However, Tony does not consider that Mike has lost learning opportunities and may face a loss of ownership of his assigned work to the OSV.

Nora points out that there will still be some tension upon Mike's return; the students did Mike's work when their own work was not yet complete. However, she converges towards Tony's characterization of a "reasonable person".

> *"But then there's also the dynamic of like "oh why did they do my work when they're not done. when their work isn't done. It depends on if you know Mike is a reasonable person, like how he'll take it that other people changed his work." (Nora, line 247)*

Nora highlights a dynamic that Tony missed – the students were not done with their own work before they started doing Mike's work. She points out that Mike may resent his teammates particularly because they should have been doing her own work. However, Nora shares Tony's "reasonable person" positioning. She also defines a reasonable person as one who will not react negatively to their work being changed while they are out of class. The LA class converges around how a "reasonable person" would respond to this situation.

Quinn, one of the role-play students, responds to the tension that Nora highlighted - that the students had changed Mike's work. Nora agrees that they are taking over Mike's work when he has only been absent for one class.

> *"I guess we changed his work" (Quinn, line 248)*

> *"Yeah, you know, you changed the design. You're taking his work and he hasn't been there in a few days" (Nora, line 249)*

> *"Just one" (Jackelyn, 250)*

“Okay, just one” (Nora 251)

Quinn recognizes that the students changed Mike’s work, suggesting that he had maybe not connected the work on the circuits problem with taking over another student’s design. Quinn and Nora recognize the weight of changing Mike’s work while he is out of class. Pushing back against Nora’s construction of Mike’s absence as a persistent issue, Jackelyn clarifies that Mike has only been missing for one day, adding to that weight.

Tony asks for more clarification about why the students decided to take over Mike’s work. Quinn talks about how his character, Colin, is concerned about the chassis’ construction.

“I'm assuming there's a reason why you guys weren't doing your own work.” (Tony, line 252)

(students nod no) (line 253)

“No, okay” (Tony, line 254)

“It's just I'm worried about the chassis being put together. So, that might be the only reason.” (Quinn, line 255)

“Huh, we missed that completely, actually” (Tony, line 256)

“We shouldn't have been trying to help them with the chassis (?)- that would have like um not even got in to taking over Mike's work” (Lexi, line 260)

Tony asks the students for the reason the students took over Mike’s work, rather than doing their own. The students respond by saying that there was not a reason (beyond the prompt) as to why they had decided to take over Mike’s work. Quinn cites his character’s anxiety as a reason for starting work on the circuits rather than finishing the chassis. With some surprise, Tony acknowledges that the instructors had missed that the students had taken over Mike’s work before finishing their own. Lexi suggests that the instructors should direct the students to do their own work rather than take over Mike's work. Although the learning assistants converge on the fact that the students should not have taken over Mike's work, their reasoning is technocratic, not social. The students had been assigned technical work that was not close to completion, so the students had the responsibility to do their own work. Neither empathy for Mike nor attention to his learning opportunities drive the LAs' decision.

The new information that Stephen brings to the learning assistants shift how the LAs perceive the situation. They move away from talking about the order in which to prioritize the problems. They discuss the tensions related to the students' taking over Mike's work while he is out sick. They write off any of Mike's negative feelings as invalid due to the error in his work. Ultimately, the LAs clarify that they overlooked that dynamic and should have directed the students to do their own work.

Discussion

As the learning assistants discuss the tensions that emerged during the role-play, they uncover more nuances in the role-play setting and improvisations. In this section, I describe how the sociotechnical divide, empathy, and technocracy arise during the whole class discussion.

The social-technical divide

The sociotechnical divide is evident during the first act, as the LAs describe the tension between solving the circuits problem and the attendance problem. As the debrief begins, the learning assistants characterize two competing problems in the role-play; they perceive there to be a technical "circuits" problem and a social "absent students" problem. The learning assistants frame the two problems to be separate from one another. Because they do not consider how the problems might be interconnected, the LAs pit the attendance problem against the circuits problem. Jackelyn, who wrote the role-play prompt, reinforces this tension as she invites the rest of the class to weigh in on the tension that Tony and Kurt articulated rather than asking how the two problems may be interrelated.

The technical/social dualism is further exacerbated by Quinn's fabrication of the deadline. As the resource of time is made scarce by the presence of the deadline, the LAs decide that the circuits problem is more important than helping students navigate the problem of their teammates' absences and communication problems. They converge around solving the technical problem rather than addressing the social problem.

Further adding to the sociotechnical dualism, Lexi describes the intervention around the social problem as "unsatisfying" (line 218). Later, Tony refers to the technical problem as "cut and dry" (line 246). In doing so, the learning assistants are both reflecting and reproducing engineering culture, in which social problems are seen as messy and ill-defined, while the engineering related problems are cast as clear cut and with definite solutions (Riley, 2008).

When Stephen points out that the students had taken over their absent classmate's work before having finished their own, the learning assistants start discussing how Mike might feel when he returns, rather than trying to prioritize solving the social and technical problems separately. When the LAs connect Mike's absence to the work that they helped the students with, they no longer discuss the two problems as separate from one another. This information implicitly bridges the sociotechnical divide. The LAs stop conceptualizing the role-play issues as separate problems after this point.

In summary, during the first act, the LAs describe two problems that emerge during the role-play. They perceive the two problems as in contention with one another and discuss how they prioritize solving those problems. This divide is reinforced by the instructor, who asks the LAs how they will go about solving those problems. Ultimately, they move away from distinguishing the social and technical problems from one another.

Empathy

Batson and Ahmad (2009), who treats empathy as an emotional state, conceives of empathy as ability to take on others' perspectives and an other-oriented emotional response. In the role-play discussion, Jackelyn urges her students to take on Mike and the team's perspectives. Yet, during this debrief, the learning assistants easily empathize with some students, but have a more difficult time empathizing with others, including Mike.

During the role-play, Quinn's character, Colin, is concerned about an upcoming deadline. The learning assistants orient to this anxiety by helping the team with the requirements for their upcoming deadline. The introductory engineering design course has unmovable deadlines, which can cause students a lot of stress. The instructors notice Colin's anxiety around the upcoming deadline and provide support to ease that anxiety by answering the students' technical questions. So, taking the deadline seriously, which is consistent with empathy toward Colin, may have contributed to the emphasis on technical rather than social issues documented in act 1.

By contrast, in the second act, Stephen brings up that the students took over their classmate's work. Jackelyn asks the class to consider what might happen when Mike returns to class (line 234). Stephen rejects Jackelyn's bid by immediately pointing out that Mike's work was incorrect, refusing to take Mike's perspective (line 235). Tony agrees with Stephen.

Jackelyn acknowledges that Mike had an error in his work and repeats her question again; she points out that Mike's error does not interfere with them considering what will happen when Mike returns. Stephen suggests that Mike would be untrusting of his teammates because the mission team took over his work while he was out. Quinn adds that Mike would feel a loss of credibility in the work that he was doing. The LAs start to engage in the empathy process with Mike. However, the empathy quietly shifts to how the team would feel about Mike. Lexi suggests that the rest of the team would be untrusting of Mike because they found a major error in his work. Quinn agrees, saying that the rest of the team would be untrusting of Mike in the future. The LAs use Mike's technical error as a justification for his loss of status within the group and as a warrant for the group to lose trust in him.

This resistance to empathizing with Mike culminates in the conception of "a reasonable person." The learning assistants say that if Mike is a reasonable person, then he will be understanding of the changes his group made. They do not consider his loss of learning opportunities or ownership over the work. They assume that a reasonable person will not harbor or express negative feelings about their work being changed.

Technocracy

Throughout the debrief, the LAs draw on technocratic reasoning to justify their decision making. The learning assistants prioritize the technical progress of the OSV over the learning opportunities of the team—an emphasis on *product* over the learning *process*. In the first act, the presence of the deadline changes how the learning assistants prioritize the two issues. In the second act, the LAs resist empathizing with Mike, citing his technical error to justify instructing the students to take over his work (in order to help meet the deadline).

In the first act, the presence of the deadline drove the LAs' decision making. When the learning assistants thought that the students were short on time, they were forced to weigh the technical dilemma against the social dilemma. Initially Tony valued addressing the social solution first, which was unusual for Tony. Kurt points out that the students had a deadline approaching. He says that although their attendance is important, the students *needed* some technical support before the deadline. In this way, Kurt casts the technical progress as "needs" and the attendance problem as secondary. As Tony becomes aware of the presence of the deadline, his prioritization of the issues shifts and his reasoning becomes more technocratic. When the students are short on time, Tony values the technical progress of the oversand vehicle over team communication and addressing the team's missing classmates.

In the second act, technocratic prioritizes contribute to and are reinforced by the LAs' resistance to empathy for Mike. Even after they tentatively take Mike's perspective, the learning assistants more naturally take the perspectives of the rest of the mission team, rather than Mike. The LAs' inclination towards empathy aligns with the character's technical correctness.

The learning assistants ultimately decide that the students should not have been working on Mike's work; however, their reasoning is technocratic rather than empathetic or learning-oriented. The students were assigned technical work that they were not near completing, and hence the students had the responsibility to do their own work. Neither empathy for Mike nor attention to Mike's learning opportunities are a part of the learning assistant's reasoning.

Positioning: local power dynamics during the discussion

As the learning assistants grappled with harmful ideologies emerging in the role-play, local power dynamics emerged during the whole-class discussion. As the only returning learning assistant, Tony positioned himself as an expert. As an "expert," Tony positions himself, and is positioned by the rest of the class, as having more credibility. When he shifts to prioritizing the wiring problem over the attendance problem, the rest of the class follows that lead and also converges towards the technocratic solution.

When Stephen points out that the students took over Mike's work when their own work was not complete, Jackelyn uses her right as the instructor to ask the class to consider what might happen when Mike returns to class. She shifts the direction of the conversation from thinking about what occurred to the implications of what occurred. Stephen immediately responds to Jackelyn's bid by pointing out that Mike had an error in his work and Tony agrees. The LAs position Mike as "incorrect" and so it is now their right to not consider how he might feel when he returns to class. Because Mike is "incorrect," the learning assistants have the right to not consider how he might feel.

Jackelyn acknowledges that Mike might be incorrect but uses her right as instructor to ask the class to still consider what will happen when he returns to class. Although the LAs take up Jackelyn's bid to envision the interaction when Mike returns to class, they continue to refuse to consider his feelings, constructing the idea of a "reasonable person," who would sideline their feelings in pursuit of technical progress.

Local power dynamics influence the whole class discussion. Conversation participants use their positions, such as instructor and expert to influence the structure and direction of the conversation. As instructor, Jackelyn leads the whole-class discussion and has a right to make bids for the direction of the conversation. As an "expert," Tony positions himself as knowledgeable and credible. His statements are given a lot of weight as the class converges on prioritizing the technical progress. The learnings assistants position Mike as "incorrect," and use that positioning to resist Jackelyn's initial bids.

Instructional Implications

The role-play discussion has implications for courses on engineering design and for the preparation of learning assistants who co-instruct those design courses.

Mundane, taken-for-granted aspects of engineering design courses, such as deadlines and group work where not everyone is present, create conditions that favor progress on the product over the students' learning process and opportunities, even though the purpose of such courses is to teach design thinking. Many engineering design courses contain similar unmovable deadlines. Furthermore, those deadlines often heavily contribute to the students' grade in the course. So the technical progress of products, rather than a students' learning, is critical for students' academic success.

In this role-play, these structural features served to take away a fictional character's learning opportunity; but in the classroom they can serve to perpetuate harm. If the deadlines had flexibility or were personalized for each team depending on where they were at in the design process, then students' learning experiences might be prioritized over the technical progress. Furthermore, assessment targets within engineering design courses might also be redesigned to explicitly support learning, rather than focusing heavily on product development.

Jackelyn, one of the pedagogy seminar instructors, wrote the multifaceted, classroom-based role-play prompt, providing the learning assistants with the opportunity to grapple with a dilemma that had both social and technical elements. Jackelyn also invited the students to consider the outcomes of their teaching moves. The discussion allowed the LAs to unpack the role-play events and reflect on the tensions which arose during that role-play. Without the debrief, the learning assistants would not have recognized how the two problems intersected and would not have explored the downsides of letting the student take over Mike's work. My analysis highlights, however, how despite Jackelyn's best efforts, the learning assistants still resist prioritizing the social aspects of engineering design in their instructional decision-making, partly because of their technocratic prioritization of product over process. My contribution here is not an instructional technique that breaks down this resistance, but rather, an increased understanding of why the resistance is so strong: it arises, in part, from technocratic ideals deeply baked into engineering and engineering education culture.

Chapter 5: Concluding Remarks

Summary

In this dissertation, I studied how inequities arose and played out in two interactions which occurred in STEM learning spaces. These interactions demonstrate how inequities can arise from mundane, classroom situations.

In the first body chapter, I argued for curriculum developers to monitor the kinds of group dynamics their worksheets (or other written materials) create. I used an illustrative example where the wording in a tutorial contributes to an unproductive group dynamic; one of the students is given a secretarial role that excluded her from conversation around the conceptual tutorial questions. This analysis explored *how* this inequity emerged and persisted, even after initial confusion was resolved. I call for curriculum developers to monitor the impacts on group dynamics during the testing phases.

In the second body chapter, I analyzed a discussion which followed an engineering learning assistants' role-play in a pedagogy seminar. The role-play scenario intertwined social and technical issues. After initially considering prioritizing the social/teamwork problem over the technical issue, the learning assistants converge around decision-making that prioritizes the technical issue. I highlighted how harmful engineering ideologies, such as social-technical dualism and technocracy, underlie and are locally reproduced in LA's reasoning and instructional moves.

Equity implications – "taking up space"

Victoria Hand conceptualizes equity as the ability for students to "take up space"; equitable classrooms are those which support a broad range of student participation, where students feel comfortable sharing their ideas (Hand, 2012, p. 237). This conception of equity speaks to the moment-to-moment nature of the inequities captured in my dissertation body chapters.

In the illustrative example in chapter three, Zoe is assigned by her teammates into the role of the computer controller. In this role, Zoe is given space to operate the computer and determine the order in which experiments are tested. However, after her teammates think she made an error, her teammates command her to do certain moves, rather than suggest. After the team realizes that she did not make an error, she regains ownership over the computer controls. However, as the conversation progresses, she is both physically and intellectually excluded from her teammates' conversation around the tutorial questions. As she tries to contribute to those conversations, her utterances are ignored by her teammates. She is busy with the computer, so she is unable to face her teammates. In the illustrative example, Zoe is denied physical and intellectual space.

In the discussion following the role-play in chapter four, Mike is denied current and future space in his engineering team, even though he is absent. During the role-play, other students are unchecked as they change Mike's portion of the work without letting Mike participate in those changes. Although the LAs ultimately decided the students should not have taken over Mike's work, the reasoning the learning assistants use is that the students should have done their own work first, rather than giving Mike that space and decision-making power over his work. Mike's access to space is backgrounded in the learning assistants' decision-making process.

In Hand's paper, some of the teachers want to empower their students to take up space, not just in the classroom but in society (Hand, 2012). Hand focuses on how teachers can create the conditions in their classes where students feel comfortable taking up space. The notion of "taking up space" is not limited to just the classroom and learning spaces, but to their humanity and treatment as whole people. In my dissertation chapters, Zoe and Mike are both denied space; they're denied the opportunity to contribute and fully be themselves.

Positioning: regulating multi-dimensional power in interaction

In both chapters, local power dynamics impact how the conversation unfolds. In particular, the local power is carried in the positions that were available to and taken by the participants. The contexts of the two data sources differ, which results in different positions and rights available to the participants. The rights that are available to certain positions mitigate the power that the participants have in certain positions.

Chapter three

In chapter three, three students were working together on a worksheet. There is no formal hierarchy or roles within this group. Within the first few seconds of working, Zoe is asked to control the computer for the duration of the worksheet; she obliges. In this moment, she was assigned and accepted the role of being in control of the computer. As the interaction unfolds, controlling the computer takes her attention away from the worksheet-generated conversation. Her teammates do not wait for her to be ready to join this conversation. As she tends to her responsibility controlling the computer, her groupmates charge ahead on the worksheet. Although they catch her up before moving to the next question, she misses out on the opportunity to sense-make around the topics. As Zoe controls the computer, she translates this conversation into computer moves in the simulation. She is able to transform the conceptual ideas that they are talking about into actions in the computer simulation.

As computer controller, Zoe has the right to control the computer and the order of experiments. When her teammates ask her to run a test again so that they have a baseline to compare the next one to, Zoe says that she will run that simulation next (chapter 3, transcript 2, lines 15-18). As computer controller, Zoe has the right to determine the order of when things appear.

In the position of keyboard controller, Zoe has non-uniform power. On one hand, she determines the order and events that occur during the simulation. On the other hand, she lost access to sense-making conversations. Although she exhibited competence translating the conversation into simulation experiments, typically grades in introductory physics courses are based on conceptual and mathematical understanding. In the role of computer controller, she did not have access to that kind of reasoning. The position of computer Zoe's case shows that conceptualizing a student as having "more power" or "less power" in an interaction does not capture the nuances and multi-dimensionality of power.

Chapter four

In chapter four, there is a more traditional classroom dynamic, with a hierarchy between the instructor and the students. The instructor has the responsibility of leading the discussion, and therefore has the right to make bids for the direction that the conversation takes. Only one student was a learning assistant the previous year. He positions himself and is positioned by the other learning assistants as a more experienced learning assistant. Because of this position, in the discussion his contributions are given a lot of weight.

In addition to their formal roles, societal roles, such as gender, shape the discussion. Early on in the conversation, Jackelyn notes Kurt's and Tony's differing perspectives. She opens the discussion up to the rest of the class (chapter four, line 208). However, Tony ignores Jackelyn's bid and responds to Kurt. Although I cannot ascribe sexist intent to Tony's actions, this dynamic replicates sexist, societal level patterns. Perhaps Tony's self-positioning as expert gave him the right to do that.

Although Jackelyn holds power in the position of the instructor, she is positioned in society as a woman. On one hand, her bids carry weight as she is the instructor and is grading the students. However, Jackelyn presents as a woman, who are often talked over. This combination of positionalities regulates the power that Jackelyn has. Tony, as an experienced or expert learning assistant, may have thought he carried the right to ignore Jackelyn's bid and continue the line of conversation.

The multi-dimensionality of power

In both chapters, local power dynamics are regulated through the positions available to and taken by the participants. In Zoe's case, her role gave her certain rights but also took away some of her rights as a conversation participant. In Jackelyn's case, her formal role gave her some rights but, even in a position of power, sexist dynamics continued. Even though both Jackelyn and Zoe held some power in the conversations, they lacked power in other dimensions. Across both chapters, local power is non-unidimensionally distributed in both formal and nonformal ways.

Methodological contributions

The design of learning environments

In this research, I used discourse analysis to attend to how interactions shape learner's experiences. Often, when we study learning, we operationalize and assess learning in ways that remove the learning outcomes from people's lived experiences. Interaction analysis avoids this flattening; students' learning can be "assessed" in its natural context, not divorced from their emotions and overall experience of the learning environment.

Both body chapters are situated in research projects which aim to refine STEM learning spaces. In chapter three, I argue for curriculum designers to incorporate observations into their tutorial refinement process. In chapter four, I assess how the learning assistants reason around group dynamics part of the way through the semester, partly with the goal of refining the next instantiation of that pedagogy seminar. By incorporating interaction analysis into the refinement process, I learned more about how the learning spaces impacted my participants' in-the-moment experiences. In this research, I aim to acknowledge and understand harm in order to create a more equitable learning environment.

How interaction analysis sheds new light into research areas

In chapter three, I realized that the tutorial contributed to the unproductive group dynamic only because I carefully watched and transcribed the interaction. From an initial pass at the data, I was aware that Zoe was excluded from the conversation. Using interactional sociolinguistics, I was able to "see" how microaggressions were constructed and continued throughout the work session. From this analysis, I identified elements of the curriculum that were contributing factors to the inequity, while acknowledging that racism and sexism likely played a part in this interaction as well. If I had used traditional measures only, such as pre-post testing, I would have missed the unproductive group dynamic entirely. If I had interviewed the students, I don't think I would have been able to pinpoint the elements of the tutorial that had contributed to this negative dynamic. As I watched the dynamic unfold, I saw how the tutorial and the simulation interacted to produce this negative dynamic.

In chapter four, I traced cultural pillars through learning assistants' decision-making processes. Specifically, I investigated how the presence of a deadline causes the LAs to converge on prioritizing technical interventions and to background social interventions. By looking at the post-role-play discussion, I can see how the social-technical divide, technocracy, and empathy are both explicitly and implicitly present in the learning assistants proposed instructional moves around the role-play scenario.

So, the analysis of the post-role-play discussion shows how engineering cultural pillars are present in conversation and in instructor's sense-making around problems. While ethnographic studies have investigated engineering culture (Faulkner, 2007; Tonso, 2006), my work focuses on how peer educators recruit cultural elements in their reasoning around instructional moves. With interaction analysis, I am able to trace how empathy, the sociotechnical divide, and technocracy shape the LAs' interpretation and prioritization of the issues in the role-play scenario.

The relationship between structural and local inequities

In this dissertation, I focus on two different grain sizes of inequities, local and societal. Each body chapter primarily focuses on one of those grain sizes, however, the local and societal inequities play out in both of those scenarios. In this section, I discuss the relationship between these levels of inequities in each of the chapters.

In chapter three, a local interaction reproduces a broader, societal pattern. Zoe is asked by her classmates to control the computer because she is the closest. In this role, the computer occupies her attention. After an error is attributed to Zoe, when she does contribute to the conceptual conversation, her ideas are acknowledged but not taken up by her groupmates, despite being cleared of that error. As computer controller, Zoe takes on a more secretarial, lower status role. Since Zoe presents as a Black female, while her groupmates are both Asian males, this dynamic reproduces broader societal racist, sexist, and intersectional dynamics.

In chapter four, the learning assistants recruit harmful ideologies as they reason about a teamwork trouble. Although the learning assistants were not aware that they instructed the students to take over their missing teammate's work, they resist considering how that student might feel in favor of technical progress. They recruit technocratic reasoning to defend their actions. So, in this case, structural level inequities feed into the hypothetical, local inequity, where the absent student, Mike is shut out of his work.

Methodological implications

Although both chapters draw on interaction analysis, studying different grain sizes of inequities, local and structural, required attention to different features of the conversation.

When probing for local dynamics in chapter three, I investigated metalinguistic features of the interaction, such as speech speed and pitch, to determine inflection and tone. I also analyzed the students' body language to investigate which students had access to which space. This was connected to the positions were available to the students.

In chapters three and four, local power dynamics are described through the positions which are available to and taken by participants. These positions describe the rights (or power) and responsibilities. Zoe, for example, has the responsibility of controlling the computer, but the right to determine the order that experiments occurred in. Another way I investigated local power dynamics was by looking at how the participants oriented to what other participants shared. For example, Tony ignores Jackelyn's bid to open the conversation to the rest of the class. Tony responds to Kurt instead. In this chapter, Tony takes power.

In chapter four, I analyzed how common, harmful mindsets influenced how the learning assistants reasoned about a teamwork trouble. While investigating ideologies, I looked more at the substance of the speech and how the learning assistants implicitly and explicitly framed the teamwork trouble. I looked at how they proposed responding to and solving the problem to determine their mindsets. I also looked for shifts and convergences in the learning assistants' framing of the problems.

Teamwork troubles and structural inequities

Teamwork troubles become inequities when they deny someone full personhood. This can occur both at an interactional and a structural level. In chapter three, Zoe is assigned into the role of the keyboard controller. This position restricts her access to the conceptual conversation, a place where she makes bids to communicate; these bids were not taken up and continued in the conversation. She is denied the chance to participate. When she is positioned as keyboard controller, she is flattened into that role.

Inequities can also be embedded in instructors' response to teamwork troubles. In chapter four, when the learning assistants realize that the students took over their missing classmate's work, they do not acknowledge that they made a mistake. They value the technical progress of the OSV over their students' experiences and learning opportunities. Although societal patterns of technocracy do not initially play out in the teamwork trouble, the learning assistants deny considering Mike's feelings due to his technical error.

Limitations

Chapter three, *Rethinking the divide*, is constrained by the amount and type of data that was available. The data was collected with the intention of refining tutorials. At the time, I did not gather demographic data about the students and was not able to interview the students about their experiences in the small-group work. These limitations prevented me from being able to connect the local inequities to broader, societal patterns.

Chapter four focuses on a role-play; the learning assistants are making instructional decisions about fictional students. This data therefore limits us from investigating how technocracy and other cultural narratives that the learning assistants recruited during the role play would affect their diagnosis of their *actual* students' teamwork troubles. In the role-play, the learning assistants do not have an existing relationship with the "students" and do not know the nuances of the team. If the learning assistants had real relationships with these students and knew their group project, would they have made the same decisions? The available data limits the ability to pursue these questions.

Future research directions

In this section, I propose several areas for future work across both projects.

Continuing the current analyses

In chapter three, I include an illustrative example to supplement my argument that curriculum developers can and should attend to group dynamics. I suggest several changes to the tutorial, ranging from revising the tutorial section which caused the students' confusion to explicitly asking students to switch computer controllers and to discuss group dynamics. For more immediate future work, the impact of these changes could be investigated. On a longer time scale, it would be worthwhile to investigate elements of collaborative tutorials that may promote productive team dynamics and allow students to feel comfortable taking up space.

The role-play and discussion in chapter four demonstrate how the learning assistants recruited technocracy in their reasoning over one day of the semester. As the semester progressed, the learning assistants engaged in more discussions around equity and design thinking. This study does not investigate how a learning assistant's thinking changes during and after the semester-long pedagogy seminar.

Empathy for whom?

In chapter four, I discuss how the engineering learning assistants resist empathizing with Mike, citing his technical error as a reason to not take his perspective. In a conference proceedings paper, I analyzed another role-play where the learning assistants intervened in a situation where an overbearing student with wacky ideas talked over a quieter student, Molly, with tenable ideas (H. Sabo et al., 2019). In both role-plays, there is a student who is unable to advocate for their own ideas: Mike is absent, and Molly keeps getting talked over. However, Molly has "good ideas," while Mike's work contained a major technical error. The learning assistants urgently ensure that Molly is given space to share her ideas, while Mike's feelings and learning opportunities are not considered by the learning assistants. I am interested in a cross-case analysis looking at how technical progress aligns with the learning assistants' empathy.

Closing

Like many other education researchers, I want to make learning environments better spaces. In this dissertation, I focus on studying students' interactions, which shape their experiences. As we enter the digital age, particularly under the Covid-19 pandemic circumstances, education has transitioned away from in-person learning spaces towards online and hybrid spaces. As asynchronous learning becomes increasingly prevalent, Hand's notion (Hand, 2012) of space-taking becomes more relevant. We must ask, how can we holistically care for our students and create environments where they can take up space in asynchronous situations? If education is not carefully redesigned, online learning will reproduce current inequities.

Appendix A: Literature Table

Paper	**Focusing on What? ↓**	**Methods**	**Focus of Tutorial**
McDermott, L.C., Shaffer, P.S., 1992	Misconceptions-oriented, conceptual change	Interviews to find common misconceptions	Electric Circuits
Shaffer, P.S., McDermott, L.C., 1992	Misconceptions-oriented, conceptual change	Comparison groups, pre-post tests	Electric Circuits
McDermott, L. C., Shaffer, P. S., & Somers, M. D., 1994	Misconceptions-oriented, conceptual change	Comparison groups	Tension – Atwood's Machine
Wosilait, K., Heron, P. R. L., Shaffer, P. S., & McDermott, L. C., 1998	Misconceptions-oriented, conceptual change	Pre-post testing, interviews for misconceptions	Light & Shadow
Ambrose, B. S., Heron, P. R. L., Vokos, S., & McDermott, L. C., 1999	Misconceptions-oriented, conceptual change	Pre-post testing, interviews for misconceptions	Electromagnetic waves
Wosilait, K., Heron, P. R. L., Shaffer, P. S., & McDermott, L. C., 1999	Misconceptions-oriented, conceptual change	Pre-post testing, interviews for misconceptions	Geometric optics / diffraction of light
Heron, P. R. L., Loverude, M. E., Shaffer, P. S., & McDermott, L. C., 2003	Misconceptions-oriented, conceptual change	Pre-post testing, comparison groups	Buoyancy / Archimedes' principle
Kautz, C. H., Heron, P. R. L., Loverude, M. E., & McDermott, L. C., 2005	Misconceptions-oriented, conceptual change	Pre-post testing, interviews for misconceptions	Ideal Gas Law
Cochran, M. J., & Heron, P. R. L., 2006	Misconceptions-oriented, conceptual change	Large scale identification of misconceptions, pre-post testing, comparison groups	Heat engines

Isvan, Z., & Singh, C., 2007	Misconceptions-oriented, conceptual change	Pre-post testing, comparison groups, interviews for misconceptions	Coulomb's Law, Gauss's Law
Lindsey, B. A., Heron, P. R. L., & Shaffer, P. S., 2009	Misconceptions-oriented, conceptual change	Large scale identification of misconceptions, pre-post testing	Work & Extended systems
Guisasola, J., Zubimendi, J. L., & Zuza, K., 2010	Misconceptions-oriented, conceptual change	Comparison Groups	Electrical Capacitance
Close, H. G., Gomez, L. S., & Heron, P. R. L., 2013	Misconceptions-oriented, conceptual change	Pre-post testing, interviews for depth / process of learning	Dynamics of rigid bodies
Chang, S. L., & Shaffer, P. S., 2018	Misconceptions-oriented, conceptual change	Large scale identification of misconceptions, pre-post testing	Rolling motion
Lindstrøm, C., & Sharma, M. D., 2011	Level of scaffolding & student preference**	Comparison Groups, observations, focus group	Forces & energy
Bao, L., & Redish, E. F., 2002	Analogical scaffolding	interviews for misconceptions, comparison groups	Probability in quantum mechanics
Podolefsky, N. S., & Finkelstein, N. D., 2007	Analogical scaffolding	Pre-post testing interviews, comparison groups	Electromagnetic Waves
Kuo, E., & Wieman, C. E., 2015	General Rule vs Contrasting, analogical scaffolding	Pre-post testing, comparison groups	Electric field & electric field potential
Lin, S.-Y., & Singh, C., 2015	Analogical scaffolding	Comparison groups, interviews	Forces
Shemwell, Jonathan T.; Chase, Catherine C.; Schwartz, Daniel L., 2015	General rule vs. contrasting cases	Pre-post testing, comparison groups	Electric Flux
Chase, Catherine C.; Shemwell, Jonathan T.; Schwartz, Daniel L., 2010	General rule vs. contrasting cases	Pre-post testing, comparison groups	Electric Flux

Gette, C. R., Kryjevskaia, M., Stetzer, M. R., & Heron, P. R. L., 2018	Dual-process theory & cognition	Comparison groups, interviews	Buoyancy
Elby, 2001	Epistemology	Pre-post testing	Question type: epistemological focused curriculum
Hu & Rebello, 2014	Epistemology	Group interviews	Question type: Hypothetical Debate Problems
Redish & Hammer, 2009	Epistemology	Tutorial observations, pre-post testing	Course reform, including development of tutorials

Appendix B: Copy of the tutorial

An Introduction to Orbits

I. Orienting with the simulation

Go to http://phet.colorado.edu/en/simulation/legacy/my-solar-system (or Google PhET My Solar System) and open the "My Solar System" simulation.

Spend **5 minutes** playing with the simulation and exploring its features.

A. What is one unexpected thing that you found while playing with the simulation? Why was it unexpected?

B. What does "system-centered" mean?

Notice that if you use your mouse to hover over a body, you get its position and velocity components.

[Page Break]

II. Gravitational Force

There's a slider on the bottom right. Turn the slider so that it is 1/4 of the way between accurate and fast (closer to accurate). Also, make sure that System-Centered is turned on.

A. The Gravitational Field

Go to the **ellipses** preset. **Change the initial velocities of each of the planets to zero.**

A. Record the distances between the sun (body 1) and each of the planets (bodies 2, 3, and 4). Note that the sun is not at the origin.

Body 1: _____ Body 2: _____
Body 3: _____

B. Predict what will happen when you run the simulation. Explicitly compare bodies 2, 3, and 4 to each other. Explain your reasoning.

C. Run the simulation.

a. Describe what happened to each of the three small bodies.

b. Is this this what you expected? Why did it behave this way?

D. Now, make the following changes to the first case (ellipse preset with initial velocities set to 0), predict what you think will happen to *the three small bodies*, run the simulation, and record what actually happened, comparing it to the behavior of the initial case, specifically looking at *how long* it takes the planets to collide with the sun.

First Case	What happens?	Where is the planet closest to the sun? Where is the planet furthest from the sun?
Sun and planet preset		
Increase the planet's initial velocity by about 20%.		
Decrease the planet's initial velocity by about 20%.		
Increase the planet's initial velocity by a lot.		
Decrease the planet's initial velocity to 0.		
Without using math, explain to a middle school student how the planet's initial velocity affects whether and how the planet orbits and why.		

E. Two students are asked about how doubling the mass of the planet affects the gravitational force between the sun and the planet.

Student 1: When I doubled the mass of the planets, the motion remained the same. So, the gravitational force does not depend on the mass of the planet.

Student 2: But the gravitational force comes from the interaction of the two bodies; so it depends on both of the mass of the sun and the mass of the planet.

Student 1: If the force is twice as big, how come the smaller bodies didn't fall any faster?

With which student do you agree? Explain your reasoning.

F. Let's tie this whole section together. Why does changing the sun's mass affect the motion, but changing the planet's mass doesn't?

Appendix C: Transcription Key

Conversation Analytic Transcription Conventions

(from: Waring, H.Z. (2015). *Theorizing pedagogical interaction: Insights from conversation analysis*. New York: Routledge.)

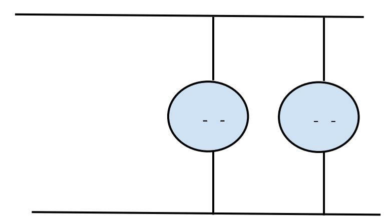
.	(period) falling intonation.
?	(question mark) rising intonation.
,	(comma) continuing intonation.
-	(hyphen) abrupt cut-off.
::	(colon(s)) elongation of sound.
word	(underlining) stress.
word	The more underlining, the greater the stress.
WORD	(all caps) loud speech.
°word°	(degree symbols) quiet speech.
↑word	(upward arrow) raised pitch.
↓word	(downward arrow) lowered pitch.
>word<	(more than and less than) quicker speech.
<word>	(less than & more than) slowed speech.
<	(less than) jump start or rushed start.
hh	(series of h’s) aspiration or laughter.
.hh	(h’s preceded by dot) inhalation.
(hh)	(h’s in parentheses) inside word boundaries.
[ ]	(brackets) simultaneous or overlapping speech.
=	(equal sign) latch or contiguous utterances of the same speaker.
(2.4)	(number in parentheses) length of a silence in 10ths of a second.
(.)	(period in parentheses) micro-pause, 0.2 second or less.
( )	(empty parentheses) non-transcribable segment of talk.
((gazing toward the ceiling))	(double parentheses, italics) nonverbal activity.
{ }	(brackets) simultaneous verbal and nonverbal conduct
(try 1)/(try 2)	(two parentheses separated by a slash) alternative hearings.
$word$	(dollar or pound signs) smiley voice.
#word#	(number signs) squeaky voice.
LL	double Ls- more than one learner

Appendix D: Role-play prompt handout

Roleplay scenario (Students handout)

For a team, Team Fire, they have assigned 3 people on the chassis construction, 3 on mission (Abe, Colin, Bee), 1 on motor-circuits (Mike) and 1 on programming (Kal). Abe on mission hasn't shown up for a couple days in the beginning but now is turning up to class. Kal on programming seems to be doing his stuff but not really talking as much to the others. Colin on mission is worried about where things are going. They have their chassis roughly put together -- at least the base, the motors and motor mounts. But the motors are not connected to circuits. So, no electronics. Their OSV has 4 motors, one per wheel.

So on Monday, the TA sees that Colin, Bee, and Abe are just standing around and asks them to find some stuff to do. About 30 minutes later they approach the TA to ask about circuits. They have the following picture on the page (see to right). Colin has a pen with the picture on a page. Bee, on one side of Colin, has her laptop open to look things up. Abe is standing on the other side of Colin.



Colin and Abe ask the TA how to connect the motors and batteries. The TA notices that they have two batteries. There is a single wire going from the negative end of one battery to the positive end of the other battery. The batteries are 6V 2000mAh Tenergy packs. Colin says that Mike and Kal had said that the two batteries would be connected together since they wanted the batteries to last longer. Colin, Bee, and Abe are not sure how the batteries need to be connected. When pressed they can draw out connections that show that the batteries were planned to be in series, but they aren't sure of this terminology.

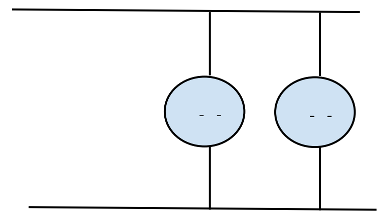
Unfortunately, Kal and Mike are absent today. Mike wrote an email saying he was sick, but no one knows why Kal isn't there. This is the first time that Colin, Abe, and Bee are dealing with circuits, to make up for Mike and Kal not being there. But they are feeling a bit out of depth with the whole thing.

Bee, Abe, and Colin have access to the report that they submitted, but they don't have the values such as current draw of the motor, voltage of the motor, etc handy.

Roleplay Scenario (Instructor Handout)

For a team, Team Fire, they have assigned 3 people on the chassis construction, 3 to mission (Abe, Colin, Bee), 1 on motor-circuits (Mike) and 1 on programming (Kal). Abe on mission hasn't shown up for a couple days in the beginning but now is turning up to class. Kal on programming seems to be doing his stuff but not really talking as much to the others. Colin on mission is worried about where things are going. They have their chassis roughly put together -- at least the base, the motors and motor mounts. But the motors are not connected to circuits. So, no electronics. Their OSV has 4 motors, one per wheel.

So on Monday, you see that Colin, Bee, and Abe are just standing around and you ask them to find some stuff to do. You notice that Mike and Kal are absent. About 30 minutes later they approach you to ask about circuits. They have the following picture on the page (see to right). Colin has a pen with the picture on a page. Bee, on one side of Colin has her laptop open to look things up. Abe is standing on the other side of Colin.



Colin and Abe ask you how to connect the motors and batteries. The TA notices that they have two batteries. There is a single wire going from the negative end of one battery to the positive end of the other battery.

[NOTE: the student teams have more information on their design - as is natural in actual classroom. We do want you to think about technical as well as intra-team communication and process-management issues that the team might be facing. The idea is to practice how to balance these different aspects when interacting with teams.]

Brainstorm before roleplay

(1) What explanations are you considering for this group's troubles? (Ex. Maybe no one on the team has social sensitivity? Maybe they aren't communicating between sub-teams? Maybe they don't know circuits? Maybe they aren't prepared to handle absences?)
(2) What would you want to notice to hone in on a robust explanation?
(3) How might you want to intervene/act?

Information that team looks up in the report from the section that Mike wrote:

The motors have an operating voltage of 6V and an operating current of 1A.
P_all_motors = (4xI_motor)x(4xV_motor) was used in the battery calculations.

Appendix E: Transcript of the second role-play and whole class discussion

Line	Speaker	Text
1	Jackelyn	So, team, you will almost have to redo this, but you already observed what some of the things about their uh, their personalities or about their team. So the starting point, I think would be, the same place. Where you're bringing what you've drawn, what you've drawn about your circuit to the team, the instructional team and asking them for thoughts about your **indistinguisable**
2	Quinn	Can we switch roles?
3	Jackelyn	*(Turns to ask Chandra)* Do you want them to switch roles?
4	Chandra	Oh no, just between Abe and the other person, if you want.
5	Jackelyn	If you want to, sure! Um, but then, the instructors need to understand that
6	Quinn	*(To Stephen)* Do you want to be Abe?
7	Stephen	Uh sure.
8	Lexi	What are your names then?
9	Stephen	I'm Abe
10	Jackelyn	If you two want to switch, that's fine. So, you're Collin now?
11	Stephen	Um, am I?
12	Tony	Whoever's Abe, you're the one that sucks at circuits, right?
13	Quinn	I think Collin is like...
14	Jackelyn	Collin is the one who is concerned about the battery capacity and um
15	Quinn	Collin's concerned. So
16	Stephen	I like being Abe
17	Quinn	I want to switch back

18	Parker	I'm still Bee.
19	Lexi	So, Abe (*points to Stephen*), Bee (*points to Parker*), and Collin (*points to Quinn*)
20	Students	(*Nod in agreement*)
21	Jackelyn	Same roles. And you already have a feeling for what the team is like now, but we're still going to start from the same- the beginning of them coming to you for help about their circuit. [00:01:23.423] ROLE-PLAY BEGINS
22	Lexi	So, what seems to be the issue, guys?
23	Q/C	So, two of our members who made our circuit didn't come in today. They also did our report. And we have our chassis. The physical components put together; we have the motors mounted on the board. But-
24	Tony	Pause. Quick second.
25	Jackelyn	Yes
26	Tony	Is this strictly open hours or during class. Cause that would change the (brief pause) whole teammates not showing up drastically
27	Jackelyn	Yes, that's absolutely correct. Um, so the scenario was framed as class time. I was just thinking I don't know why there's uh three people in the room. Maybe it's just because a lab fellow just during class time. So, let's not make it open labs, good point. Um, in terms of absences, that's very relevant, so let's do class time. As was stated in the scenario, the instructors approached you all (*Jackelyn points from the instructors to the students*) because it seemed like you weren't doing anything. They asked you to work on something and you're now coming back thirty minutes later having worked on this electrical schematic. This is what you've drawn.
28	Q/C	Yeah. So, we have the motors mounted. So, we need our vehicle to be driving, but we don't have any electronics hooked up. For past half an hour, Bee and I were trying to work towards it. And this is
29	S/A	I was too.
30	Quinn	(*dismissively*) Yeah sure. (*Laughter from audience/actors*) So this is the drawing that we came up with. I know, um Kal and Mike said

		that they want. They're worried about the battery life of our OSV. So, they said to use two batteries and connect them in series. I'm not exactly sure what that means. But they said that that will double our battery life to last long enough for our mission
31	Lexi	So, what's the trouble that you're having right now?
32	Q/C	So, (*holds out hands for the whiteboard, passes it to Parker/Bee*)
33	P/B	So right now (*draws in collaboration with Quinn. Stephen has his hand on his chin. While Parker is drawing, Lexi whispers something to Nora. Tony taps his head in response to whatever they say. The mic had a hard time capturing the talk*)
34	P/B	Yeah, and then I don't know what happens on this end, but yeah, that's how the thing is (*hands it to Lexi*)
35	S/A	That looks right
36	Q/C	I think you can just put the other sides motors on the other side, so we didn't draw this
37	P/B	Yeah yeah
38	Q/C	So, there's just one side on there
39	P/B	Yeah, just one side.
40	Lexi	So,
41	Tony	Before we get to this- more importantly. How- Why are your teammates not showing up to class time?
42	P/B	Mike's sick. I don't know where Kal is.
43	Q/C	He's probably talking to his girlfriend
44	Tony	Is this a common theme of them not showing up?
45	P/B	I mean no
46	Tony	Is this like a one-time thing or has it been recurring?
47	Q/C	Well, Kal just doesn't really communicate with us. He'll get his work done, but we don't really understand how he did it or why he did it. He just doesn't really tell us what he's doing.

48	P/B	Especially cause like we're on the chassis. And then Kal is on programming, so we don't really have anything to do with each other. So, we just haven't been talking about any of this stuff.
49	Q/C	And Mike is on circuits and motor. So, this is probably like his role. He's supposed to be able to put everything together
50	Tony	So, like- we can easily help you and walk you through this, but the more important issue is that you're not working together as a team. That you don't know where Kal or Mike are. And you guys are not communicating
51	S/A	I mean we know-
52	Tony	Have you guys-
53	S/A	I mean we know Mike is sick
54	P/B	Yeah, Mike's sick
55	Q/C	Yeah
56	S/A	But Kal, we still don't, I think it's just sorta like, I mean, I don't know. He's here sometimes.
57	Tony	Are you guys expressing your uh concern in the lack of communication, or Kal not showing up.
58	Q/C	Well, Kal will normally show up, he's just not a talker
59	P/B	Yeah, he just doesn't talk
60	Tony	Okay
61	Q/C	He kind of just hides in a corner
62	Tony	Okay
63	P/B	It's just programming
64	Q/C	That's like what comp-e (computer engineers) in the least do, right?
65	Tony	(*laughs)*
66	Lexi	(*jokingly*) I take offense to that

67		(*All actors laugh*)
68	Tony	Do you think it would be better if she had dominate this (this is what I hear - I really can't make out what it actually is)
69	Lexi	Um, I mean. So yeah, you have said something about this though?
70	P/B	*(high pitched noise of non-commitment)* Eeeeeehn
71	Tony	Have you tried talking to Kal?
72	Q/C	We tried (*emphasis on tried*) talking to Kal
73	P/B	Yeah (*pitch falling*)
74	Q/C	It's just hard to communicate
75	Nora	Maybe you should, um, express your concerns and hopefully Kal will come around
76	Lexi	Did you, uh, when you first started do like your team norms and stuff. At the beginning of the semester. Did you, um, have any protocols in place for communication
77	P/B	No. But we should've had some things in place for communication and presence on the showing up.
78	Lexi	Yeah, definitely. Maybe, even though it's the middle of the semester. I mean, I guess, not to single them out, but um, maybe you could do that now?
79	P/B	Yeah
80	S/A	Yeah, but Kal is also contributing his fair share. I don't see what a huge problem with people being absent, if they're contributing.
81	Lexi	Yeah, that's true
82	Tony	Him being absent is the exact situation that we're in now. Um, you don't know what's going on with your own OSV and you have to come to us to help with your own OSV. But if Kal was here, he would be able to communicate with you guys effectively enough so that you wouldn't need our help right now.

83	Q/C	Well Kal is just doing work on programming. I think Mike would be able to help with this, but Mike is just sick and-
84	Tony	Yeah, okay
85	Lexi	That's excusable
86	Q/C	But our deadline is coming up. We need our OSV to be driving. And right now, nothing is connected. Nothing is driving.
87	Lexi	Yeah, so do you want to try to have you guys (*indistinguishable*) right now? And then um,
88	P/B	Yes, we can start working
89	Tony	Yeah, worry about that later.
90	Lexi	So, basically we've established that Kal and Mike are excused for now. Cause Kal is contributing, he just doesn't talk much and he's not here. And Mike isn't here, but he's usually here
91	P/B	Yeah, yeah
92	Lexi	And are you guys happy with that?
93	S/A	I mean,
94	P/B	We could be happier, but it is what it is
95	S/A	Yeah, like no
96	Q/C	(*indistinguishable*) (brief pause) at least they have good ideas.
97	P/B	Yeah
98	Tony	Okay, so we can turn the attention to the circuit for now and then get back to that later.
99	Lexi	Okay, first issue is, what's up with these batteries?
100	Tony	Do you know what the positive end-
101	P/B	But they're connected.
102	Tony	Of, the positive end and negative end are for each symbol?

103	S/A	I mean Mike mentioned an H-bridge. That sort of looks like an H. So, I figured that was right
104	P/B	Yeah, that's what I was going for
105	Lexi	So that's actually not what an H-bridge is
106	A/B/C	Oh
107	Lexi	So
108	Q/C	So that's not an H right there?
109	Lexi	It does look like an H. But it's not H-bridge
110	Tony	Where are your batteries if you thought that was the H bridge?
111		(brief pause)
112	P/B	Is the H-bridge not involved with the battery?
113	Q/C	Like someone told us the H-bridge like gives power.
114	Lexi	So actually, the point of the H-bridge is to enable to motors to drive either forwards or backwards. So, I'm just gonna draw an H-bridge right now, if that's okay. So, here's an example motor. Right? And then you have switch here, switch here, switch here, and switch here. And you can see that these are actually going to be transistors in your circuit. But transistors are switches, at least in this case. So, um you can see, this line sort of represents a switch saying whether the wire is open or closed. And if it's open, then no current will flow, so it's like it's off. Right? So, (*draws more*) and here's your battery. So, it is connected to the battery, you were right about that.
115	S/A	We have two batteries
116	Lexi	Two batteries, okay. So, okay. Before, okay. Holding this in your mind. Let's go back to the battery situation. Is that okay?
117	A/B/C	Yeah
118	Lexi	Alright
119	Q/C	So we were that the batteries should be in series, that way it's twice as much battery life

120	Lexi	Okay, so that's actually wrong. It's the opposite. So, actually, if it's in parallel then, the more batteries you have, the more life you have. And the reason for that is because say you have batteries in series, right. The way that voltage works is that it's just like the difference between two points. So if you have two batteries in series, then the voltage is twice as much, but the same amount of current is going through them. Does that make sense?
121	S/A	Yes
122	Lexi	So, you have one path, right, current is going through them at the same time. And the same amount of current is going through this battery as this battery. But if you batteries in parallel, like this, then half of the amount of current is going through each battery. And you can kinda think about current as what eats up battery life, right? So, when you have half as much current going through each battery, then they'll last twice as long. But the drawback to that is the voltage between this point and this point is twice as much as the voltage between this point and this point. Does that make sense?
123	Q/C	mmm
124	Lexi	So whatever voltage you need for your motors
125	Q/C	So
126	Lexi	If you have them wired like this, it will be twice that
127	Q/C	So, we have 6 volt batteries.
128	Jackelyn	I just want to remind the report tells you how much voltage the motors are supposed to run off of.
129	P/B	Oh, so if we look at our report
130	Q/C	Okay
131	P/B	It says that the motors have an operating voltage of 6 volts and an operating current of one amp.
132	Lexi	Okay, so what is- what voltage are your batteries?
133	Quinn	We're using 6 volts.
134	A&B	6 volts

135	Lexi	So, you would want them in parallel like this. Right?
136	P/B	Uh,
137	Q/C	Would that affect how much voltage they have?
138	Lexi	So, because what I was saying before. What's standard in the battery. So if it's a 6 volt battery, on either side of the battery, there's going to be 6 volts. So, on this, on either side, there's a difference of 6 volts. And then on here, either side, there's a difference of 6 volts. Right?
139	Q/C	Uh huh
140	Lexi	So, between here and here what would the difference be in this circuit
141	Q/C	Six
142	P/B	Twelve, oh.
143	S/A	Okay
144	Q/C	Yeah twelve
145	S/A	I mean I don't know. There's just a bunch of lines and I don't understand what they mean. but it's fine. You can just move on. It's fine, I'll just learn it later. Really, really, it's okay
146	Lexi	Okay, okay. Okay. And then here, you have six volts between here and six volts between here. And as you can see, so these represent wires, right? And these are the batteries. Um, and voltage is the same all along the wire until you hit a component. So, because this difference is six volts and this difference is six volts, and the voltage is equal here and equal here. That means that the difference between here and here is also six volts. But because the difference between here is six volts. Imagine that this- at this point, we're going to call it zero volts. Right, so if the difference up through here is plus six. Then at here, we're at six. Right? And at here, the difference plus here is six, then we're at 12
147	S/A	Oh
148	Lexi	So, the total difference between these two is 12. But here, it's not like that and you can understand that the difference is six, but the current going through them is half. Does that make sense?

149	S/A	Okay, yeah
150	Lexi	Okay
151	S/A	So, if series is like, positive and negative connected. What is uh parallel?
152	Lexi	So, this one is parallel
153	S/A	But like the wires though. What do the wires look like?
154	Lexi	Yeah, well, it's kind of basically exactly like this (points to diagram) but in the real world. Does that make sense? It's like if you have to imagine that the lines are wires. On a drawing, it might look like this, in the real world, it might look more like this. Or if you have a connection like that. However it's connected, the important thing is that it splits off or it's one final path. Okay, this is really messy. Is it okay if I erase some of this?
155	Q/C	Yeah
156	Jackelyn	Do either of the other two instructors want to say anything?
157		(*Lots of students talk - Jen adjusts something, Lexi erase*)
158	Tony	I mean, she's got it.
159	Lexi	I'm sorry
160	Tony	I wasn't trying to correct you. I was thinking about it to myself that you said switches to make it simpler. That was my bad
161	Lexi	Okay, now that we've got that sorted out, we know that this isn't right
162	P/B	Yeah
163	Lexi	So how should it be? I'm gonna let you guys draw how the batteries should look
164	Q/C	Okay (takes board)
165	P/B	Just gonna... (*Parker and Quinn start working on it, leaving Stephen out*) So, there's nothing here, right?
166	Q/C	So, we just put the battery. I think that looks right

167	Lexi	Awesome, that means that each of the motors are getting 6 volts, right?
168	Q/C	Yes.
169	Lexi	And then you're getting twice as much battery life because half of the current is flowing through each of those batteries.
170	Q/C	Okay yeah, that makes sense
171	Lexi	Okay, yeah so now that we've got that sorted out, do we want to look into how to implement H-bridges, or are we good for now?
172	P/B	I think we're good for now.
173	Q/C	Yeah, I think we're just gonna
174	Jackelyn	I wanna ask one thing of you all, what next steps would you give them for the remainder of the hour of class time? Now that they feel like they understand what's going on here?
175	Tony	Well, they did just say something about a deadline correct? You guys said something about some deadline
176	Q/C	Yep, the milestones like next class
177	Tony	So, if the Romeo was there in front of us, well I can't do it. Hmm, how do I say this? Yeah, I would do what Lexi, what we just brushed up. Walk through the Romeo wiring, what we just drew. But we can't do that without the Romeo.
178	Jackelyn	So, what I'm suggesting, do you want to to go tell them to go build now. To build that circuit. Do you want to tell them. What do you want them to do for the next hour? Should you tell them okay go build?
179	Lexi	Well, since you guys said your deadline was fast approaching, I do think it would be a good idea to build. Because then if you still don't understand something. Like it made sense to you in theory, but then in reality, it's not working for some reason, then you can be on the path to debugging. And if you think it's wired right, and it's not working, then you can ask one of us to come help you. But, yeah, because definitely the thing about your teammates is still an issue, you don't really have unlimited class time, but you do have unlimited time to text them and ask if you could change some things.

180	Nora	I would also suggest updating um Kal or whoever wrote the report. And be like, this is just kind of what we're going with now. And call us back if you have a question.
181	P/B	Parker: Alright
182	Q/C	Alright.
		[00:18:20.158] END OF THE ROLE-PLAY. CLASS DISCUSSION BEGINS.
183		(*Class claps*)
184	Jackelyn	Okay, so thank you all. Uh, thank you students and thank you instructors for engaging like that. Now, the five instructors, I'm hoping will have some observations to share. Let's hold off in a moment. I want to first ping the students and see from your perspective, if there's anything you noticed about um or wanted to comment about. Perhaps you were trying to convey something subtly and it wasn't getting across or um your impression of the feedback that was given to you. And then let's perhpas ask the instructors to share what they just went through as well. Students, anything you'd like to share
185	Parker	I thought Tony and Lexi were both very patient with us. And like, it was like
186	Jackelyn	I'm sorry, you said that who?
187	Parker	Tony and Lexi were patient with us. And you know, walked us through what we did wrong?
188	Quinn	I think we were making it difficult
189	Parker	(*Parker laughs*)
190	Quinn	Parker and I were bullying Stephen.
191	Stephen	Yeah
192	Quinn	Because he hasn't been showing up. So, he's kind- just like we don't care about his ideas
193	Parker	We don't trust him

194	Quinn	That's definitely hard for an instructors to see that our open frustration
195	Stephen	It's hard for Abe too. (*Laughter from several people*)
196	Stephen	I like that Lexi didn't brush off my lack of understanding
197	Parker	Yeah, I was gonna say that.
198	Stephen	You followed through
199	Jackelyn	Anything else from you three?
200	Parker	(Parker nods no)
201	Jackelyn	So, one small thing that was different from the two sheets that I'll point out is that they know that Mike was sick and the instructors didn't know that Mike was sick. And you ended up pulling out that information. Okay, so let's ask the instructors. First you all were the observers. So, did you have any thoughts as you were hearing the exchange happen that then informed your own choice on how to approach this. Or from your own experience, having done it now, any thoughts or observations?
202	Tony	I think the first time around, they didn't talk about the students not- address what I think was a bigger problem- that the students weren't showing up to class. Um, cause they just said that Mike and whoever the other guy was
203	Quinn	Kal
204	Tony	just weren't there. So, that should be like an immediate bell of a problem before you dive into the circuit mess
205	Jackelyn	Okay, so figuring out the attendance issue or talking about it was something that you found valuable? (short pause, calls on Kurt)
206	Kurt	So, I actually had the uh opposite feeling. In the sense that they said that the deadline was coming up, they should figure out what they needed to do for like, I was thinking that was an important thing to realize that some students aren't showing up, but I think that it should have been done after um, they got what they needed
207	Tony	(Tony grabs the instructor sheet from Lexi)

208	Jackelyn	Alright, so there's interesting then um decision to be made. Which do you address first? Do you address the technical issue of their batteries, or do you address teamwork issues? Any thoughts on that? Since the two groups did it very differently. And perhaps what the students who chime in if you wish.
209	Tony	I mean there's nothing about um a deadline coming up on the sheet, so that's why we started off with that. And then when they said "We have a deadline coming up, we diverted to the circuit problem.
210	Quinn	So, it wasn't an issue on our sheet
211	Tony	Yeah, you just made it up
212	Quinn	My role was, I think my role was that I was just supposed to be worried. So, I was like
213	Parker	(*Parker laughs*)
214	Quinn	I just gave my team members
215	Stephen	We've got a deadline coming up in six weeks.
216	Jackelyn	Right, so Collin should be worried. Okay other observations from instructors
217	Nora	I think there was like Kurt mentioned there was now, you know, so we just kinda tackled the issue with the people who are here now. And it kinda seemed like a positive spin on addressing the attendance issue. Although it wasn't directly stated. But um, I think that was a good thing to say. Like your other teammates aren't here. We can still like fix this problem, so I thought that was a good thing to say to them
218	Lexi	I felt like it was kind of unsatisfying for the first and second round. We tried to talk about the attendance issue more for the second round. But we still didn't really come to like a good conclusion
219	Jackelyn	About how to handle the attendance issue
220	Lexi	Yeah, we definitely like brought it up more. But we still didn't really like, come to anything else to do besides like, because they said they had already talked to them. And we didn't really have any other advice besides like talk to them more.

221	Tony	I think in both cases, parsing the fact that Quinn just made up the deadline. But like if there wasn't a deadline, we could have spent more time on it but, it is more important because there is a deadline, that is the more pressing matter
222	Quinn	I had to add a spin to it.
223	Stephen	I think that you guys-
224	Jackelyn	May I ask you to let Abe talk
225	Stephen	I think that something was that was sort of missed was that we were working on electronics at all. Cause like supposedly, the instructors told us to just do something and we chose to do electronics even though we're the mission team. So, like
226	Quinn	We **indistinguishable**
227	Parker	Yeah, it's not done
228	Stephen	The chassis is barely complete. We have to like build in all of the mission completion stuff.
229	Kurt	wait, the chassis not completed?
230	Parker	No, like the wires and the tires aren't on or anything
231	Stephen	There's no wheels and no mission specific things.
232	Jackelyn	So, going along with that
233	Tony	That's a good point
234	Jackelyn	One of the thoughts that I had was um, so what if, so Mike is, in theory, been working on some of these things. What do you think would happen when Mike comes back the next class. If you guys have started implementing these changes
235	Stephen	I mean, he thought series would increase the battery life, which is a major issue
236	Tony	Yeah
237	Jackelyn	Okay, so if he's wrong, I'm wondering still what will that interaction be like? What can you imagine about that interaction when he comes

		back and now things have been changed? Whether he was, it seems like he was wrong
238	Stephen	It seems like he'd be pretty untrusting of the group because
239	Jackelyn	Untrusting? Okay
240	Stephen	Yeah cause like when the mission team
241	Quinn	Yeah, maybe like a loss of credibility in the work he's been doing.
242	Lexi	Probably like you guys would be untrusting.
243	Quinn	Yeah, like we would be untrusting of Mike
244		(brief pause)
245	Parker	Also like, I don't know how, cause it was really like me and Quinn were both really.
246	Tony	I mean Parker said she was going to, or Nora told Parker to text them about the changes. So, assuming that occurred, and Mike is a reasonable person, then I don't think he would get frustrated because he was wrong in that case. But if it was a design decision that they made without Mike being there, then that could result in some conflict. But because it's something that's mostly cut and dry and Nora instructed Parker to tell them, tell Mike of the changes and the fact that he talked to the TAs, then I don't think there'd be too much conflict, as it would be like, Mike would start untrusting his own teammates.
247	Nora	But then there's also the dynamic of like "oh why did they do my work when they're not done. when their work isn't done. It depends on if you know Mike is a reasonable person, like how he'll take it that other people changed his work.
248	Quinn	I guess we changed his work
249	Nora	Yeah, you know, you changed the design. You're taking his work and he hasn't been there in a few
250	Jackelyn	Just one
251	Nora	Okay, just one

252	Tony	I'm assuming there's a reason why you guys weren't doing your own work.
253		(*students nod no*)
254	Tony	No, okay
255	Quinn	It's just I'm worried about the chassis being put together. So, that might be the only reason.
256	Tony	Huh, we missed that completely, actually
257	Stephen	Yeah
258	Jackelyn	You missed what
259	Tony	We missed that completely
260	Lexi	We shouldn't have been trying to help them with the trough(?)- that would have like um not even got in to taking over Mike's work
261	Tony	Yeah
262	Lexi	And stuff if we had just been like. Don't even be working on this stuff.
263	Tony	Don't work on this stuff, work on your own stuff. Why are you working on this, it would have just solved everything?
264	Jackelyn	What do you all think of that?
265	Kurt	I think if it were an actual situation, where we have this teaching environment, where we were trying to figure out something. Like I think the whole point of this was to actually work on the electronics maybe? Like, talk about that with them. but if it were me, actually in the lab or like during class, it might have been a little different, because you as the instructor in the class, would have had a bit more of an open mind when we're thinking about the different possibilities to share with them
266	Jackelyn	So, in pursuing it, you think there were opportunities to learn about electronics that you think they would not have otherwise had the change to engage with them.
267	Kurt	Yeah

268	Theo	(Theo nods)
269	Jackelyn	Try, restate what you were going to say right there.
270	Kurt	Um, so like, so we were talking about how like, we should have gone, we should have told them to go work on their chassis, instead of worrying about the electronics. Basically, what I'm trying to say is that um since, we were I guess, put into this simulation sort of thing. Where we as educators were trying to help them with the specific problem that they were having, I think we were just like, alright let's help them with this, rather than thinking of the broader idea of helping the whole group. Um, like in general. Cause if we were like maybe in class, you wouldn't have this, like we wouldn't have like this thing in the back of our heads that we were kinda forced to go through the circuits thing.
271	Jackelyn	So, your impression was that the prompts were making you think that you should focus on the electronics.
272	Kurt	Yeah
273	Jackelyn	I will also say that the bottom parts here do have some questions about, um, social sensitivity about communication. There were some thoughts there about the dynamics of the team, in a natural setting. This, it would be more natural to talk about the team and other issues when the whole team is perhaps there
274	Nora	I think you're right. In that, that shifting gray line is like really tricky. Like if someone comes to you and says, oh my god, I don't know how to make sense of this electronics circuit, it's kind of hard to maintain that kind of frame that the students are bringing to like this conversation. Should I stay then, in this electronics frame, or should I zoom out and ask them like where are different components in the project at? And like, how does this electronics thing fit into it? Right, cause you're right. It requires deviating from the invitation that the students have started with.
275	Jen	I think it's possible, that if it's your students, in your class that you've been in the whole semester, you'd have a better sense about where everyone is already. Like you'd have a better sense about the team, just from interacting with them. That would already provide more directions for you to go in
276	Lexi	I have to say, if somebody did come up to me and ask me specifically about one technical issue that they did not understand, I would not be at all thinking about like um what would- what their team dynamics

		are. And if I were the student in that situation, I would be kind of annoyed if I'm trying to get this information that I need and then the instructor is like "oh, how's everything going in your team. Like, just you're not answering my question that I asked you, you know?
277	Jackelyn	I feel like that could be a sense of- that could be a reflection of what a lot of what we're doing is. Like some of you have mentioned in your inquiry that instead of answering a question, you've been asking more questions. Do you think that that's worth it? Do you think that we should be answering the question? It's frustrating for them
278	Quinn	I think that you can like build up to it. So, like, if someone does come up with a circuit question like that, you can ask them to draw you what they think- how they think it should be wired up. And they like don't know what they're doing, maybe they're not the ones who are supposed to be wiring the circuit and that's when you can ask things like that. For me, it's not like me to ask, is this your role on your team, but if I see someone struggling with something that they should have a better understanding of, then you can ask about team dynamics like that
279	Jackelyn	Right, so maybe, instead of asking, is your team okay? As you're asking them, for them to draw and explain it. If their struggling, you can ask them, is this um does someone else have this already drawn out. Or maybe there are ways to invite, like are there other teammates that we could be asking, that we could be bringing in.
280	Lexi	Yeah, and then if they say, yeah! we're really annoyed about this, then that's a whole different thing. Because they're asking for help about that
281	Jackelyn	So maybe, a perspective could be to, while you're addressing the help, try in your mind to ask questions that can probe further as well. So, like, I don't know. Trying to balance between those two. While asking student to explain, it might invite some more information.
282	Tony	But, if you're trying to, I don't want to say, limit, but like limit the students to what they were assigned. Like a mechanics student to just mechanics, or like construction portion, and not electronics, wouldn't you like shielding them off, or like isolating them to a specific portion. Cause that's at least like what E says happens for every team. Um, you're only going to know a certain part of the OSV. No one's gonna know every part of the OSV unless they did it all by themselves. So, is that a problem, or is it fine that students only know a certain part of the OSV?

283	Quinn	So, I feel like, when it does, when it comes to that. Like a student like a chemical engineer wants to learn how to solder, he'll like kind of start with. He'll come up to you like- I don't really know how to solder, I'm a chemical engineer. I've actually had two of my students like-
284	Tony	Yeah
285	Quinn	Start a question like that. Um, like so maybe, I'm assuming that will be the natural progression. Like that's where they think they'll begin
286	Tony	I think, wait no go ahead
287	Stephen	No no, I was just gonna say, I think the first thing that I would do is just like answer the question. Cause like, best case scenario, it's like, they're in charge of the team, and it's like crucial to the design to get the question answered. Worst case scenario, they learn something new and it won't take more than like 5 minutes
288	Tony	Yeah. Cause I always default into the question. I don't really think about is this your role on the team or is this something you should be doing. I've never thought of that. Cause even if that's not your role on the team, if you don't know how to solder, if you don't know the difference between series or parallel, that would not be beneficial moving forward.
289	Lexi	Yeah, and if they're asking, they clearly wanna know. Whether they're frustrated about it or not.
290	Jackelyn	Right, so while you're answering the question, what if you didn't find out more about the team. Would that be okay? So you've now taught them about their circuit, that's a plus! right? You're saying Stephen, now they're coming away with a better understanding of the circuit of their OSV. It's worth knowing that. Um, but what if you don't know anything else about the team?
291	Lexi	I think that's fine
292	Tony	I think that's the point of the peer evaluations. Um, I think that's why we should have more peer evaluations. Like one right before build phase starts, and then as it moves forward, like have maybe 3 instead of two. I think that's what we have at least in instructor1's class. But, I think every class has two right? Two peer evaluations
293	Jackelyn	No, it's up to the instructor.

294	Tony	But
295	Quinn	Is it two during the build phase? Sorry
296	Tony	Yeah, instructor1 has two during the build phase. One a couple weeks in. One towards the end. Right before milestone- right after milestone 7
297	Jackelyn	So, I'm trying to- I'm kind of wondering if you're taking back what you just played out. Like when you say that you shouldn't be inquiring about the team? That you should be focusing on addressing the concern they've come to you with
298	Tony	If they've come to you with a question then, I believe, as of now that the question has priority over everything else I agree with that
299	Lexi	But, that doesn't mean that the team dynamics isn't important. The teammate dynamics are also important. Just not in relation to the
300	Tony	question. So, you can get the team dynamic information by the peer evaluations, is how I've always done it
301	Lexi	I think if this were a real situation, I wouldn't have asked about the team at all. Um, I guess that's already clear, but um, like uh, the main reason why I felt like we even did ask about the team, like any of us, were that like, it was low key asking for it on this handout
302	Tony	Yeah
303	Lexi	Yeah
304		(*short pause while Jackelyn writes on the board*)
305	Jackelyn	And Kurt, you had your hand up
306	Kurt	Uh yeah, just to like kind of go off that. Maybe a reason why we just kind of, just don't even think about the group as a whole is because sometimes we're biased towards questions. Just in the like "hey I can answer that, so I'm going to answer that"
307	Tony	Yeah, for sure
308	Kurt	"Because that will make myself look much better"
309	Tony	I don't know about that

310		(Class laughs)
311	Kurt	Or like, or like, um, sort of like building up trust with students. That they can come to you with anything. Designing a person, or like coding, or like circuits all day cause like I'm pretty familiar with them. But anything comes to like mechanical stuff, there's no one to talk about. I don't want to **indistinguishable** it
312	Lexi	I know what you mean
313	Jackelyn	So then, besides the peer evaluations, are there any other ways that you would be open to and learn about team situations. Or do you feel like that's not really your role?
314	Tony	I think a certain percentage of it you can. There will be some false positives, as in people that look like they're not doing anything. But they're not as technically um- advanced, to say as other students. So they show a lot more effort for like milestone two, three, eight, and nine. But for the most part, you can tell if students are absent. Um, you can tell if students aren't doing anything or are doing other work in class. And if it's a consistent problem, then you can maybe approach the team about it. But there are some cases where you can't tell if the student is doing something or not doing something. And it's up to the students- the team- to come to you for advice on how to handle it. If they don't, it's almost as if they don't need that person. Cause, eight people is a lot for this project. You can do it with less than that. So, that's my two cents.
315	Jackelyn	Do you view the um, the UTF and instructor roles differently in terms of how to either get yourself involved with the team or not?
316	Tony	Depends on the instructor
317	Jackelyn	Mmm
318	Tony	I think Instructor2 in the past, cause I've only had experience with instructor2 and instructor1. I think instructor1 is a lot more independent. I don't actually think he knew any of the students' names before the end of a few semesters ago. But I knew all my students' names. But instructor2 knew all our names like two to three weeks in. And knew how the team dynamics were working better than my TA at that time, which was Maria*. Like he knew that I was like the one doing all the work and coming in during hours, and my team wasn't. Um, so it would depend on the instructor and TA.
319	Jackelyn	Any other thoughts?

320	Jen	I have a question.
321	Jackelyn	Yeah
322	Jen	Alright, pseudo instructors. So, I know there was an issue with attendance. Like members weren't showing up and there was like trying to figure out who was, you know, role it was to take on what jobs. And that was an issue. But um they had mentioned that they had also. That they were like kind of subtly bullying Stephen.
323	Tony	Right
324	Jen	And I was wondering if anyone noticed that. Or what your thoughts were while it was happening or even after
325	Theo	I thought that was funny. Just in the meta, I thought that was funny.
326	Tony	Like, I, like from the context of this classroom, I couldn't tell if Quinn was doing it in a joking manner, or like a straight bullying manner. I think in the context of the classroom, it would be
327	Parker	It was supposed to be straight
328	Quinn	It was supposed to be straight bullying
329	Parker	It was supposed to be bullying
330	Tony	Yeah, but you were laughing while you were doing it (points at student). He was laughing while he was doing it. So I can't tell
331	Jen	Yeah, it felt really subtle. Even so
332	Lexi	Yeah, I thought it was like a joke too. But if it did happen in real life, I feel like I wouldn't know what to do. I definitely wouldn't like acknowledge it or anything.
333	Jen	Like in the moment at least
334	Tony	I probably would acknowledge it in the moment. Um, but
335	Jackelyn	So, if you observe- so besides you saying that you might. It's uncomfortable to do anything about it. Should we do anything about it? It seems like you all did observe what was going on

336	Quinn	Yeah, like with the two teams that had missing teammates. Like the teammates that were closer to me, they openly told me their frustrations. Like when they were doing their milestone 2 dry runs, one team was like. Yeah, she didn't do anything, but don't tell anyone that I said that. And then another team was just like, when the for teammate got sick, he was just like. I'm struggling with CAD right now, I could probably give him some, but I don't think he'd do that. So, I can see that they're just frustrated with specific teammates
337	Tony	Uh
338	Quinn	So yeah, I'm not exactly sure how I would deal with that.
339	Tony	I had a case- a case- I had a situation last semester where one of my students was, after the build phase started, he was gone for like a month. Just never showed up. And I thought it was kinda odd cause he didn't strike me as a student that would do that. Cause he was doing really well in everything else and he seemed like pretty, um, like he'd participate a lot in class. But I didn't think about it too much. And then, there was- his teammates got really annoyed with it. And when he got back they were definitely throwing um, a lot of shade towards him and um like being passive aggressive. Um, so, I pulled two of the students aside and said it's not helping your team by isolating him out this much. And then, um, I pulled him to the side and asked him what happened. And apparently his father had gotten really sick in that time and that's why he was gone. And I said, if you don't tell your team that like, why didn't you tell your team that. And he was like, I dunno, that's not really information that I want to share right now. Which I completely understand. And I said um that I guess I was kind of forcing him to share- but I said that if you're fine with what they're doing now, then like you'll just have to deal with it. I told them to stop, but if you do share that information, they'll like respect that you're here despite him being really sick. So, he eventually told them a couple weeks later, and they all realized that they can't just throw shade at him for not being there for a month without knowing the circumstance behind it.
340	Jackelyn	So, you talked with the people on the team. I'm thinking then, you might have someone tell you on a peer evaluation. You might observe it subtly. Are there any other ways that you all can think of to address it. You can talk to them directly. Are there any other suggestions? Like if we're coming to get some takeaways here. You either observe it, or someone tells you. Now what do you do? It's uncomfortable. Like Tony went and talked to them. What other options are there, besides, saying like hey. Is there anything else to be done?

341	Kurt	I don't think there are any other options besides talk to them. Like it's either talk to them or let it happen.
342	Lexi	I think you were
343	Kurt	**indistinguishable** middle ground
344	Lexi	I think you were saying earlier like you can kind of address the whole class, not singling any team out. But like, whatever policy you think would help the one team
345	Tony	I think in that case, it was for absent policies, but if it was like, people throwing shade, or constantly bullying another teammate,
346	Lexi	Yeah that's true. It'll be pretty obvious
347	Tony	Then you say like "hey, you guys shouldn't be bullying each other." Then they would pretty much know who you're talking about
348	Jackelyn	And then one suggestion, just to get more brains on it, would be to share with your instructor. So maybe like two people thinking about solutions on it might be better than just one. Okay. So, I think we're done with this. We're gonna take a break for 10 minutes
349	Chandra	I know it's like five to seven
350	Jen	Good job
351	Chandra	Yeah, thank you guys so much.
352	Jackelyn	Yeah, so let's do a break. We'll have a little bit left at the end. Can we get a picture of this? END OF CLASS DISCUSSION

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