2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #32673

Making the Most of Virtual Community Engagement for International Projects During the COVID-19 Pandemic

Angelina Nicole Rivera, Colorado School of Mines
Dr. Jessica Mary Smith, Colorado School of Mines

Jessica M. Smith is Associate Professor in the Engineering, Design & Society Division at the Colorado School of Mines and Director of Humanitarian Engineering Graduate Programs. Her research and teaching bring anthropological perspectives to bear on questions of social responsibility and engineering. In 2016 the National Academy of Engineering recognized her Corporate Social Responsibility course as a national exemplar in teaching engineering ethics. Her book Extracting Accountability: Engineers and Corporate Social Responsibility will be published by The MIT Press in 2021. She is also the co-editor of Energy and Ethics? (Wiley-Blackwell, 2019) and the author of Mining Coal and Undermining Gender: Rhythms of Work and Family in the American West (Rutgers University Press, 2014). She regularly publishes in peer-reviewed journals in anthropology, science and technology studies, engineering studies, and engineering education. Her research has been funded by the National Science Foundation, the National Endowment for the Humanities, and the British Academy.

Dr. Juan C. Lucena, Colorado School of Mines

Juan Lucena is Professor and Director of Humanitarian Engineering Undergraduate Programs at the Colorado School of Mines (CSM). Juan obtained a Ph.D. in Science and Technology Studies (STS) from Virginia Tech and a MS in STS and BS in Mechanical and Aeronautical Engineering from Rensselaer Polytechnic Institute (RPI). His books include Defending the Nation: U.S. Policymaking to Create Scientists and Engineers from Sputnik to the 'War Against Terrorism' (University Press of America, 2005), Engineering and Sustainable Community Development (Morgan &Claypool, 2010), and Engineering Education for Social Justice: Critical Explorations and Opportunities (Springer, 2013).

Prof. Robin Bullock, Colorado School of Mines
Dr. Thomas J. Phelan, United States Air Force Academy

Dr. Phelan is an associate professor in the Department of Civil & Environmental Engineering at the United States Air Force Academy in Colorado.

Prof. Kathleen M. Smits, The University of Texas at Arlington

Abstract
The Responsible Mining, Resilient Communities project is a multi-country, interinstitutional, and interdisciplinary global research collaboration whose goal is to co-design socially responsible and sustainable gold mining practices with communities, engineers, and social scientists. A key component of this work is engineering education research that investigates how *situated learning* enhances undergraduate students' *global sociotechnical competency*, especially as it relates to their ability to define and solve problems with people from diverse disciplinary backgrounds and life experiences. Situated learning refers to how students learn under different a) configurations of social relations (e.g., graduate/undergraduate; expert/non-expert; US/non-US students, etc.); b) pedagogical strategies for engineering problem definition and solution (e.g., remote vs. in-person; in-class vs. in-field); and c) different geographical contexts (e.g., in the US vs. in Colombia) affect faculty and student learning. Global sociotechnical competency refers to having the knowledge, skills, and attitudes to define and solve engineering problems as socio-technical in different international settings. *Knowledge* is understanding how engineering problems are always socio-technical and shaped by the historical, cultural, economic, and physical dimensions of a place. *Skills* are learning to define and solve problems with perspectives different than their own. *Attitudes* are the desires to continue engaging other expert and non-expert perspectives, working abroad, and serving communities after graduation.

In 2019 a diverse group of engineering undergraduate students from the Colorado School of Mines, United States Air Force Academy, and Universidad Nacional de Colombia - Medellín participated in a two-week field session in Colombia, where they visited mine sites and processing facilities, in addition to the partner university in Colombia. In 2020, however, the burgeoning COVID-19 pandemic made international fieldwork impossible. This paper will describe how we developed and executed a meaningful distance-based fieldwork experience that maintained direct engagement with international students and community members. We will offer a preliminary assessment of these methods' efficacy for developing global sociotechnical competency through remote community engagement and learning. We will analyze the situated learning of the student participants as they differently identified stakeholders for engineering projects and changed their understanding of mining as a sociotechnical process as a result of the summer session. As a part of this analysis, we will also compare 2019 (in the field) and the 2020 (virtual) learning outcomes for the two different sets of students.

Introduction

In Spring 2020 the COVID-19 global pandemic spurred significant upheavals in higher education, as many students were asked to leave campus (or their study abroad locations) and faculty were required to shift from in-person to remote/virtual classroom instruction. These upheavals posed particular challenges for engineering programs that relied on fieldwork, both domestic and international. This paper will describe how we adapted our original fieldwork plans to develop and execute a meaningful remote (virtual) fieldwork experience that maintained direct engagement with international students and community members. We will consider how this difference in format of research impacted student learning and engagement in the research process.

Funded by the National Science Foundation, the Responsible Mining, Resilient Communities (RMRC) project is a multi-country, interinstitutional, and interdisciplinary research collaboration whose goal is to co-design socially responsible and sustainable gold mining practices with communities, engineers, and social scientists. A key component of this work is engineering education research that investigates how *situated learning* enhances undergraduate students' *global sociotechnical competency*, especially as it relates to their ability to define and solve problems with people from diverse disciplinary backgrounds and life experiences. Situated learning refers to how students learn under different a) configurations of social relations (e.g., graduate/undergraduate; expert/non-expert; US/non-US students, etc.); b) pedagogical strategies for engineering problem definition and solution (e.g., remote vs. in-person; in-class vs. in-field); and c) different geographical contexts (e.g., in the US vs. in Colombia) affect faculty and student learning [1], [2]. We will explore *situativity* – the central role that physical and social context of an educational environment plays in learning – in different institutional, national, and classroom contexts. As discussed below, we understand global sociotechnical competency as having the knowledge, skills, and attitudes to define and solve engineering problems as socio-technical in different international settings.

In 2019 a diverse group of engineering undergraduate students from the Colorado School of Mines, United States Air Force Academy, and Universidad Nacional de Colombia - Medellín participated in a two-week field session in Colombia, where they visited mine sites and processing facilities, in addition to the partner university in Colombia. In 2020, however, the burgeoning COVID-19 pandemic made international fieldwork impossible so the RMRC faculty designed a two-week virtual field session for students that included daily a) presentations from RMRC faculty and graduate students on different aspects of artisanal and small-scale gold mining (ASGM); b) collaborative activities among students; c) sessions of a creative capacity building (CCB) workshop; and d) group and individual reflections on what was learned every day. The faculty and graduate students presentations included definitions on how to view ASGM as a socio-technical system, problem definition as the core pillar of global socio-technical competency, mercury use in ASGM, risk communication in ASGM, interactions between large scale mining and ASGM, listening and trust building, and environmental and public health dimensions of ASGM. The collaborative activities included re-evaluating design proposals of solutions that the 2020 cohort inherited from the 2019 cohort to three ASGM problem areas: back health of miners carrying ore out of mineshafts, remediation of tailings to be converted into construction materials, and water reuse/recirculation inside of gold processing plants. The CCB workshop included daily sessions where RMRC students witnessed how facilitators in Colombia trained ASGM community members on the design cycle to design personal protective equipment, home gardens and chicken coops to enhance safety and food supply during the pandemic. During the reflection exercises, students responded and discussed prompts related to the definition of the term “sociotechnical”, different kinds of value encountered in ASGM social relations, miners' knowledge of ASGM, and new understandings of the supply chain and environmental dimensions of ASGM.

In this paper, we offer a preliminary assessment of these methods' efficacy for developing global sociotechnical competency through remote community engagement and learning. We will analyze the situated learning of the student participants as they differently identified stakeholders for engineering projects and changed their understanding of mining as a sociotechnical process as a result of the summer session. We will show that when comparing the participants' knowledge from before the research session to after, the students displayed an overall increase in sophistication describing the stakeholders they wanted to engage, in both 2019 and 2020. Surprisingly, the data analyzed also shows that there was not as much of an increase in socio-technical competency in 2019 (in person session) as in 2020 (virtual).

Defining global sociotechnical competency

In their comprehensive literature review of engineering practice in a global context, Jesiek et al define global engineering competency as “those capabilities and job requirements that are uniquely or especially relevant for effective engineering practice in global context” [3, pg. 3]. Organizing their literature review in categories, they identified three content dimensions of “those capabilities and job requirements": a) technical coordination, b) understanding and negotiating engineering cultures, and c) navigating ethics, standards, and regulations. These dimensions are important to understand for engineers already in professional practice in corporate settings. However, our research and teaching takes place not in corporate settings but in the context of hands-on community development projects inside of engineering education settings. Hence, our notion of global sociotechnical competency departs in two ways from the dominant one summarized by Jesiek et al. First, we privilege problem definition and solving (PDS) by engineering students [4], [5]. To support the goals of community development and social justice, PDS must take place *with,* not *for,* the communities engineering projects seek to serve. This places engineering learning squarely as a *sociotechnical* rather than technical endeavor. We aspire for students to understand not only that all technical dimensions have a social component -- as suggested by the Jesiek et al framework -- but that these are always intimately linked and co-constitute each other [6]–[8]. In this way, our research and teaching is cut more in the cloth of Downey's [3] notion of technical mediation:

> In conventional definitions of engineering work, engineers have to make difficult trade-offs among alternative needs or design specifications. In the PDS model, engineers also have to make difficult trade-offs among alternative stakeholders, alternative definitions of the problem, and alternative perspectives about what is taking place,

including their own. By defining the human dimension of engineering solutions as, minimally, mediating among the positions of stakeholders, whether between the company and regulatory agency, between workers and management, among workers, among managers, and so on, engineers continue to select solutions to meet technical needs but also to reconcile differences.

Because our work is located in engineering education, the second way our research departs from Jesiek et al's conceptualization is that we draw on previous work by one of the authors that proposes a learning criterion for global competency of engineering students as: "Through course instruction and interactions, students will acquire the knowledge, ability, and predisposition to work effectively with people who define problems differently than they do." [4] In our case, *knowledge* is understanding how engineering problems are always socio-technical and shaped by the historical, cultural, economic, and physical dimensions of a place. *Skills (abilities)* are learning to define and solve problems with perspectives different than their own. *Attitudes (predispositions)* are the desires to continue engaging other expert and non-expert perspectives, working abroad, and serving communities after graduation. More specifically, we aspired for the summer session would develop the students' a) the *knowledge* that ASGM is best understood as a sociotechnical supply chain that is different between cultural contexts (e.g., Colombia vs. Peru); b) the *skills* to constructively intervene at different points in the ASGM life cycle and that these interventions require different strategies in different cultural contexts; and c) the *attitude* to work with expert and non-expert perspectives from multiple cultural frameworks in the definition and solution of problems related to ASGM.

If we combine these three content dimensions of global engineering competency from Jesiek et al (technical, cultural, normative) with the three desired outcomes of knowledge, skills, and attitudes of our definition, we end up with a very useful framework to expand the definition of global engineering competency:

CONTENT DIMENSIONS → **LEARNING OUTCOMES ↓**	**Sociotechnical coordination**	**Understanding and negotiating engineering and national cultures**	**Navigating ethics, standards and regulations**	**Socially responsible engineering**
Knowledge	Understanding ASGM as a sociotechnical system	Understanding the history and political economy of ASGM in different countries Understanding the history and political economy of engineering in different countries	Understanding legal dimensions of mining, labor & environmental management	Understanding power differentials, how to have empathy, build trust, and treat expert and non-expert stakeholders
Skills	Ability to identify different stakeholders in the ASGM life cycle and mediate among their needs and desires Ability to see how "technical" and "social" dimensions of ASGM actually co-constitute each other	Ability to operate differently in ASGM in different countries Ability to work with engineering faculty from different countries	Ability to consult experts to ensure that sociotechnical innovations/ design projects comply with legal and other regulatory standards	Ability to listen, engage in perspective taking, operate within different power positions, and work with expert and non-expert stakeholders
Attitudes	Willingness to work with expert and non-expert stakeholders along the ASGM lifecycle Willingness to open up engineering decision making to a variety of social perspectives	Willingness to work with different ASGM perspectives in different countries and engineering faculty from different countries	Willingness to ensure that sociotechnical innovations/ design projects comply with legal and other regulatory standards	Willingness and desire to engage in perspective taking Willingness and desire to work with expert and non-expert perspectives during project and after graduation Willingness and desire to use engineering to serve underprivileged populations Confidence in being able to make positive changes in communities through engineering

Methods

Data collection

Our educational research followed nearly identical protocols each summer, despite the different formats of the summer session themselves. Students completed an identical set of assessment exercises once at the beginning of the summer session and once at the end of the summer session, allowing us to compare the influence of the summer session on their knowledge, skills, and attitudes. The assessment exercises were vetted by teaching and learning assessment experts at our home university. The exercises included the following:

A one-on-one structured interview between the student and a member of the project faculty or staff. The interviews asked the students four questions in the context of ASGM in our fieldsite:

1. Who would you engage [observe, talk with, consult, ask questions to, etc] to begin defining problems associated with gold mining and processing? List as many people or types of people as you can.
2. What kinds of questions would you ask these people in order for you to understand how the problems you defined are interlinked with other places, other actors, and other areas in the gold supply chain?
3. How would you engage the stakeholders you identified in question #1 to begin solving problems associated with gold processing?
4. What kinds of questions would you ask [whom?] to understand if these problems could have different solutions if the context changed, for example, if other resources or opportunities became available?

In 2019, pre- and post-interviews were conducted in person (including post-interviews on the plane home), whereas in 2020 all interviews occurred via Zoom.

A writing exercise in which students responded to the following prompts:

1. What do you think are the biggest challenges related to artisanal and small-scale gold mining (ASGM) in Andes, Colombia?
2. What do you think the miners in Andes would identify as the biggest challenges related to their work?
3. What should be the desired outcomes of interventions to make ASGM more sustainable in Andes? Prioritize them in a list.
4. How do you think miners in Andes would identify and prioritize the desired outcomes of interventions to make ASGM more sustainable?
5. Who are the key stakeholders related to ASGM in Andes? Create a list of how you would prioritize them in the process of co-design.

6. Provide one example of a “solution” for ASGM challenges that is appropriate for the local context of Andes. Explain why it is appropriate to this specific historical, cultural, economic, and physical context.

A survey that we developed to gauge students’ a) ability to engage in perspective-taking; b) desire to learn from people with different backgrounds; c) desire to pursue engineering careers that involved humanitarian work and work outside of the US; d) personal and professional self-efficacy; and e) sense of fulfilment in engineering. Most of the survey questions came from previously validated survey instruments.

Data analysis

The data from the PIRE project for both 2019 and 2020 was analyzed for two different components. The data was first analyzed for a student-by-student change in stakeholders, including an increase in sophistication in describing these stakeholders. This data was taken from the pre and post interviews done by all the participants. Question one of the interviews asked, “Who would you engage, observe, talk with, consult, ask questions to, to begin defining problems associated with gold mining and processing?”

The stakeholders listed by each participant were then categorized into one of seven categories: making a living from mining, community, gold supply chain, government, professional experts, public health, and other. After the data was analyzed, six participant maps were made to show the students who had the largest increase in stakeholders listed, the largest decrease, and the participants whose list stayed relatively the same when looking at pre versus post.

To analyze changes in the students’ ability to conceptualize ASGM and potential sustainability “solutions” as inherently sociotechnical in nature, we coded student interview responses and essays according to the following scale of sociotechnical thinking:

1. Recognition that engineering has both social and technical dimensions.
2. Recognition that the social and technical dimensions of engineering influence each other.
3. Recognition that the social and technical dimensions of engineering necessarily imply and co-constitute each other.

This scale can be illustrated visually (though for the purposes of this paper we did not code for the social analysis of technical problems, #3 in the visual):

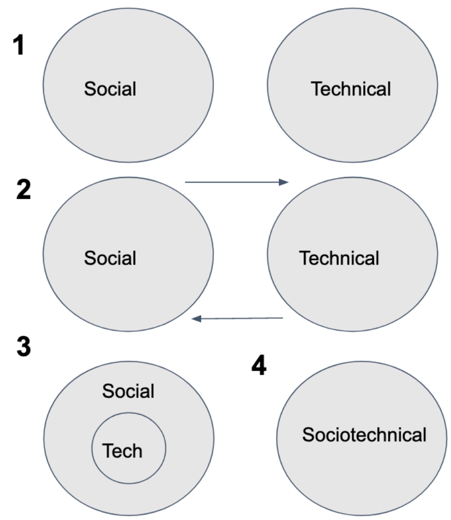

Fig 1: Types of sociotechnical analysis coded in the research

Potential limitations

As with all research, there are limitations to our study. A relatively small number of students participated. Can we say how many women participated? There were 11 students in the 2019 cohort and 8 students in the 2020 cohort. Unfortunately, due to difficulties with travel and pandemic-related logistics, not all participants completed pre- and post surveys, essays and interviews. For the 2019 cohort, only 4 students completed pre- and post assignments. For the 2020 cohort, while all 11 students completed the interviews, only 5 completed the post-survey and essay.

In addition to the different formats (in-person versus virtual), the two student groups were themselves different. Both groups included a large number of environmental engineering students and at least one civil engineering student. In 2020, a mining engineer participated, and in 2019 a chemical engineer and a geological engineer participated. Before the 2019 field session, the students all took a specialized elective course analyzing the ASGM supply chain from a sociotechnical perspective. Before the 2020 field session, the students all took an upper-division community-based, social science research methods course that also enrolled students fulfilling a graduation requirement. Though the content of the 2019 (sociotechnical analysis) and 2020 (research methods) courses were different, they were both taught by the same professor. Despite these differences, the 2019 and 2020 students were all enrolled in and identified with our Humanitarian Engineering program, which trains engineering students to promote sustainable community development and social responsibility. Many of them also shared a professional and social network through their participation as ambassadors for the Humanitarian Engineering program.

Finally, the data itself is limited because the faculty and staff interviewees did not invite students to elaborate on their answers. We created the four-question protocol above to ensure uniformity across the interviews, but this meant that students who gave short answers were not encouraged to build upon them. It is possible (and likely) that they knew or thought more than they shared verbally.

Results

Stakeholders

Through the field data from both 2019 and 2020, there is a clear distinction of change shown in the stakeholders identified by the research students as well as a change in sociotechnical competency. Across the research participants, there is a broad range of how stakeholders were identified. For the majority of the participants, more stakeholders were identified in the post-interviews compared to the interviews done before the field season. For example, participant 16 from the 2020 session listed eight stakeholders in five categories before conducting the research. This participant then listed 18 stakeholders in all of the seven categories that they believed were worth engaging for this research project.

Not only were more stakeholders identified, but there was a higher level of sophistication and understanding of the types of stakeholders available. The change in sophistication was shown in the increase of detail in the students' responses. This can be seen through the pre- versus post-interviews quotes presented below, Participant 5 from the 2019 research group and Participant 16 from the 2020 group.

Participant 5	
Pre	**Post**
"…potentially other local industries like coffee or farming…"	"…communities that are a part of surrounding businesses like farming or fishing, especially coffee"
"..maybe officials or people who regulate."	"…Entable workers and owners to see what they think about the profession."
"…people who study the environment…"	"…definitely Corantioquia…to see what their thoughts are on mining and regulations…"

Note that participant 5 changed the language they used to describe the stakeholder they wanted to engage. For example, the participant uses the words "people who regulate" and became more specific in the fact they wanted to engage *entable* (processing plant) workers and owners.

Participant 16	
Pre	**Post**
"…probably include the miners…"	"..the miners, but even within the miners, there's a heirarchy and there's different miners."
"…pay attention to power structure…interview both people who are in power and people who lack power."	"…the processing plants and everybody within the processing plants too."
"…governments…"	"…the government and any like health and safety and environmental agencies within the government would be very important because they would have a bigger overall perspective of how these small things fit together."
	"I think, too, you just have to keep an open mind throughout the whole process"

The change in understanding of beneficial stakeholders is seen in the quotes from Participant 16 through the increase in detail. For example, the participant begins the research project with the intent of engaging the government as a stakeholder, but this changes to also include health and safety and environmental agencies to provide a larger perspective. This represents the increase in sophistication of understanding of this stakeholder and the specific role it can play.

While these students both exemplify a marked increase in sophistication, we note that students in both 2019 and 2020 fell along a range. For instance, some students increased the number of stakeholders they would work with after completing their research, while others listed the same number of stakeholders or fewer. When comparing 2019 to 2020, there were more increases in sophistication in the 2020 research session. This could have been due to the fact the research was completed virtually, allowing easier access to stakeholders for some students. It could also be that although the students interacted with fewer stakeholders in 2020, they had deeper and more time intensive interactions with those they did meet.

Sociotechnical Competency

The data from 2019 and 2020 were analyzed for changes in socio-technical competency using the scale outlined in the data analysis section above. Many of the participants did progress from at least a 1 (identifying social and technical contexts) to 2 (noting how those contexts affect each other) on the scale above when comparing the pre-interview to the post-interview. This progression can be seen in the quotes below from both the 2019 and 2020 interviews (with the participant number attached to the associated quote in parentheses). The quotes below are taken from the response to question three in the interview script, “What kinds of questions would you ask these people in order for you to understand how the problems you defined are interlinked with other places, other actors and other areas in the gold supply chain?”

2019	
How does the socio-technical competency change?	
PRE	POST
"So how the work they do affect their other normal day lives their real life, not their work life." (1)	"...I'd make sure to ask about themselves, but also how they feel about certain other types of groups..." (1)
"...see how they view relationships with those people and they see how they think maybe those people impact them..." (5)	"...ask about what they see as how other industries affect their industry...Asking what they like about their work and I didn't realize the intersectionality of the workers before so asking how their jobs compared to previous jobs..." (5)
"...what challenges and problems they see related to mining...mostly to gain their understanding of what they see as issues." (9)	"...I would start asking questions about the experience both in mining and what they see as well as their experience in the community, how people view them..." (9)

2020	
How does the socio-technical competency change?	
PRE	POST
"...step me through their process of either separating the gold or whatever they daily routines may look like." (12)	"Or what is your process behind choosing mercury over cyanide or something like that, trying to give them the opportunity to come to their own answers..." (12)
"...discussing the problem that I defined with them...could you describe people who you think that might be affected by this problem?" (13)	"...start off by asking them to define the problem, to tell us how they perceive the problem being in their lives and in their communities. And then once you've defined your problem, bringing that back to them and asking them, how does this make you feel?" (13)
"Ask questions about past, present, and future - what are you trying to achieve, personal life intersection with the project." (19)	"I would ask them about the social implications of the project. I would ask them about the political affects because I never really considered that before this project and just how prevalent they are." (19)

When comparing the 2019 data to 2020 data, there was a larger increase in socio-technical competency in 2020. This was determined by more students showing a change on the outlined scale. For example, looking at the 2020 quotes above, Participant 12 increases in competency stating they would ask about daily routines and processes in general to a more sociotechnical thought process of looking at the "process behind choosing mercury over cyanide." This response indicates that the student recognizes that a "technical" decision -- choosing mercury over cyanide -- is an inherently "social" decision influenced by a multitude of factors. This student was one of the few who reached our highest level of sociotechnical competency by seeing technical concerns *as* social concerns and vice versa. This view is different, for example, from Participant 19, who instead frames social and political concerns as "effects" or "implications" of technical activities, or what we classified as the second level.

Conclusion

In summary, we compared data from two different summer sessions, one in which students traveled to our international fieldsite for two weeks (2019) and one in which students engaged in a two week virtual community engagement session due to travel restrictions associated with COVID0-19 (2020). We sought to compare the effect of the two different experiences on students' development of global sociotechnical competency. First, we examined students' identification of stakeholders for changes in sophistication of detail as well as the number of stakeholders and categories identified. Our data suggests that many of the participants increased their sophistication in understanding regarding stakeholders, but there was a perhaps surprising larger increase seen in 2020 over 2019. Second, we used a coding scheme to analyze student interviews as for any evidence of a refinement in sociotechnical thinking about ASGM. There was a slight progression in sociotechnical thinking, but not as large as we had hoped. When comparing the two years, students in the virtual 2020 session actually improved slightly more than their 2019. In future work we will examine the other dimensions of global sociotechnical competency as theorized here, such as students' abilities and desires to engage in perspective taking or work abroad.

We were disappointed to not find stronger evidence of improvements in students' sociotechnical thinking in general. In part, this can be attributed to a lack of faculty consensus about what the term "sociotechnical" actually means. It is easy for faculty as well as students to fall into the second form we identify, which views the "social" and "technical" as separate domains that influence each other. In our preparations for the summer 2021 session, we are trying to rectify this by training faculty, graduate, and undergraduate students on the most robust form sociotechnical analysis -- viewing the technical as social and vice versa.

We were also surprised that the largest improvements in sociotechnical analysis took place in 2020, as the 2019 students had taken a course that used STS concepts to theorize the ASGM supply chain as a sociotechnical one, whereas the 2020 students took a more general methods class instead. This could be because the 2019 session leaders did not take the debriefing opportunities at the end of each day in the field to connect the intense field experiences of the day to the concepts they had learned in class the previous semester. In future sessions, we will take greater care to reinforce linkages between STS concepts and field experiences. We also note that the 2020 session was biased toward more academic content (such as faculty and advisory board lectures) because we were not in the field, so it is possible that these imparted a more focused sociotechnical analysis than in the previous year.

Finally, there is a growing literature on the impact of service learning and community engagement on engineering students that we hope to integrate into our future research. For example, Zarske et al 2020 study at CU-Boulder indicates the important role that service learning courses play on engineering students' perceived skills, professional development and willingness to continue in engineering [9]. Siniawski et al 2015 from Loyola Marymount U show the impact of service-learning projects on technical and professional engineering confidence [10]. While we did not assess for any of these dimensions, we wonder, for example, if an increase in sophistication of stakeholders also results in higher confidence.

Bibliography

[1] T. D. Sadler, “Situated Learning in Science Education: Socio-scientific Issues as Contexts for Practice,” *Stud Sci Educ*, vol. 45, no. 1, pp. 1–42, 2009.

[2] A. Johri and B. Olds, “Situated Engineering Learning: Bridging Engineering Education Research and the Learning Sciences,” *J Eng Educ*, vol. 100, no. 1, pp. 151–185, 2011.

[3] B. Jesiek, Q. Zhu, S. Woo, J. Thompson, and A. Mazzurco, “Global Engineering Competency in Context: Situations and Behaviors,” *Online J. Glob. Eng. Educ.*, vol. 8, no. 1, pp. 1–14, 2014.

[4] G. Downey, “Are Engineers Losing Control of Technology?: From ‘Problem Solving’ to ‘Problem Definition and Solution’ in Engineering Education,” *Chem. Eng. Res. Des.*, vol. 83, no. 6, pp. 583–595, Jun. 2005, doi: 10.1205/cherd.05095.

[5] G. L. Downey *et al.*, “The Globally Competent Engineer: Working Effectively with People Who Define Problems Differently,” *J. Eng. Educ.*, vol. 95, no. 2, pp. 107–122, 2006, doi: https://doi.org/10.1002/j.2168-9830.2006.tb00883.x.

[6] W. E. Bijker, *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change*. MIT Press, 1997.

[7] D. G. Johnson and J. M. Wetmore, *Technology and Society: Building our Sociotechnical Future*. MIT Press, 2008.

[8] W. E. Bijker, T. P. Hughes, and T. Pinch, *The Social Construction of Technological Systems, anniversary edition: New Directions in the Sociology and History of Technology*. MIT Press, 2012.

[9] M. Zarske, D. Reamon, A. Bielefeldt, and D. Knight, “Service-Based First Year Engineering Projects: Do They Make a Difference?,” *Am. Soc. Eng. Educ.*, p. 25.1157.1-25.1157.15, 2012.

[10] M. Siniawski, S. Luca, and J. Pal, “Impacts of Service-Learning Projects on the Technical and Professional En- gineering Confidence of First Year Engineering Students,” *Am. Soc. Eng. Educ.*, p. 26.897.1-26.897.14, 2015.