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Situating Engineering Education in a World Impacted by COVID-19

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Situating Engineering Education in a World Impacted by COVID-19

Introduction

In June 2020, at the annual conference of the American Society for Engineering Education (ASEE), which was held entirely online due to the impacts of COVID-19 (SARS-CoV-2), engineering education researchers and social justice scholars diagnosed the spread of two diseases in the United States: COVID-19 and racism. During a virtual workshop (T614A) titled, "Using Power, Privilege, and Intersectionality as Lenses to Understand our Experiences and Begin to Disrupt and Dismantle Oppressive Structures Within Academia," Drs. Nadia Kellam, Vanessa Svihla, Donna Riley, Alice Pawley, Kelly Cross, Susannah Davis, and Jay Pembridge presented what we might call a *pathological* analysis of institutionalized racism and various other "isms." In order to address the intersecting impacts of this double pandemic, they prescribed counter practices and protocols of anti-racism, and strategies against other oppressive "isms" in academia.

At the beginning of the virtual workshop, the presenters were pleasantly surprised to see that they had around a hundred attendees. Did the online format of the ASEE conference afford broader exposure of the workshop? Did recent uprising of Black Lives Matter (BLM) protests across the country, and internationally, generate broader interest in their topic? Whatever the case, at a time when an in-person conference could not be convened without compromising public health safety, ASEE's virtual conference platform, furnished by Pathable and supplemented by Zoom, made possible the broader social impacts of Dr. Svihla's land acknowledgement of the unceded Indigenous lands from which she was presenting. Svihla attempted to go beyond a hollow gesture by including a hyperlink in her slides to a COVID-19 relief fund for the Navajo Nation, and encouraged attendees to make a donation as they copied and pasted the link in the Zoom Chat. Dr. Cross's statement that *you are either a racist or an anti-racist at this point* also promised broader social impacts in the context of the virtual workshop. You could feel the intensity of the BLM social movements and the broader political climate in the tone of the presenters' voices. The mobilizing masses on the streets resonated with a cutting-edge of social justice research and education at the ASEE virtual conference.

COVID-19 has both exacerbated and made more obvious the unevenness and inequities in our educational practices, processes, and infrastructures. This paper is an extension of a broader collaborative research project that accounts for how an exceptional group of engineering educators have taken this opportunity to socially broaden their curricula to include not just public health matters, but also contemporary political and social movements. Engineering educators for change and advocates for social justice quickly recognized the affordances of diverse forms of digital technologies, and the possibilities of broadening their impact through educational practices and infrastructures of inclusion, openness, and accessibility. They are makers of what Gary Downy calls "scalable scholarship"—projects in support of marginalized epistemologies that can be scaled up from ideation to practice in ways that unsettle and displace the dominant epistemological paradigm of engineering education.[1]

This paper is a work in progress. It marks the beginning of a much lengthier project that documents the key positionality of engineering educators for change, and how they are socially situated in places where they can connect social movements with industrial transitions, and

participate in the production of "undone sciences" that address "a structured absence that emerges from relations of inequality."[2] In this paper, we offer a brief glimpse into ethnographic data we collected virtually through interviews, participant observation, and digital archiving from March 2019 to August 2019, during the initial impacts of COVID-19 in the United States. The collaborative research that undergirds this paper is ongoing, and what is presented here is a rough and early articulation of ideas and research findings that have begun to emerge through our engagement with engineering educators for change.

This paper begins by introducing an image concept that will guide our analysis of how, in this historical moment, forms of social and racial justice are finding their way into the practices of engineering educators through slight changes in pedagogical techniques in response the debilitating impacts of the pandemic. Conceptually, we are interested in how small and subtle changes in learning conditions can socially broaden the impact of engineering educators for change. After introducing the image concept that guides this work, we will briefly discuss methodology and offer background information about the project. Next, we discuss literature that revolves around the question, *what is engineering education for?* Finally, we introduce the notion of *situating engineering education* and give readers a brief glimpse into our ethnographic data. The conclusion will indicate future directions for writing, research, and intervention.

Image Concept of Racial Justice

In the Chat box for the workshop discussed in the opening of this paper, the presenters posted a link to the ASEE2020 Slack Channel created by Alice Pawley (@Alice), populated by channels such as #lees-liberal-ed-slash-engr-and-society, #ethics, #hallway, and #onlin-learning-and-covid-response.[3] The channel #craftingwhileconferencing also offered an important understory to the virtual conference on engineering education. It offered refrain from the formal panels and workshops of the virtual conference through craft. It created a virtual space of multisensory epistemology and opened up an alternative digital (maker) space: "This is the very beginning of the craftingwhileconferencing channel. Description: Frivolous or fundamental to survival in a virtual conference? This channel was created for all the crafters out there who are knitting, crocheting, doodling, whatevering their way to staying focused while attending ASEE_VC. Share your projects here!" (created by @Lisa Benson).

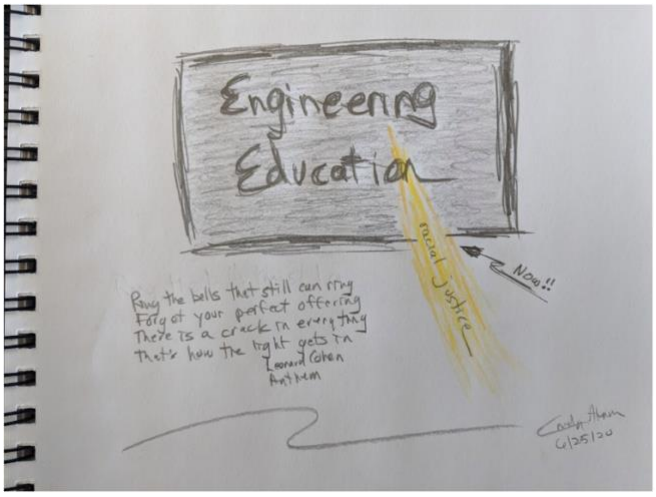

Fig. 1. Sketch by Cindy Atman (shared here with her permission) with a caption that reads: "I do sketching when I can - here is what I was working on yesterday."

Dr. Atman posted a sketch (see figure 1) in a thread of photos of knitting, a pride mini-quilt, felt applique and embroidery, two-color brioche, a doily, folded paper cranes from sticky notes, jewelry crafting, homemade sourdough bread, and strawberry-rhubarb jam. We noticed how nostalgic discourse and images of artisanal *craft* softened the sharp edges of conference spaces for professional *engineering*. These crafts also created off-screen experiences that attempted to balance the exhausting amount of time spent observing and participating in dense digital interactions. The sketch presented above captures a narrative that now permeates this text—a narrative of racial justice and scalable scholarship in engineering education. In this paper, we apply Dr. Atman's sketch as an image concept, inspired by Leonard Cohen, to see "a crack in everything" and how "the light gets in," which enables engineering educators to see the light of social and racial justice in the cracks and ruptures, fractures and fissures in infrastructures of online learning and brick-and-mortar institutions.

During moments of refrain and relief from the dense digital interactions, while catching our breath from the "Zoom-fatigue" of presentations and conversations, presenters and attendees often expressed strong sentiments and sincere wishes that we all could be together in-person to talk about these heavy, intersectional issues. Despite the resilience of engineering educators and the enthusiasm for demonstrating technical proficiency in online teaching, especially if it might help our most vulnerable students, there also seemed to be a deep reluctance to allow educational technologies displace our sensibilities of radical humanism, and further alienate relationships between students and educators.

About a month before the ASEE virtual conference, a famous author and critic of corporations and capitalism, Naomi Klein, published an article in *the Intercept* titled, "Screen New Deal." In the article, she analyzes the dystopian High-Tech vision that emerged during the first few months of the pandemic and the forced shift to online learning.[5] If the estranged labor of learning is "ubiquitous in the human situation, and most destructive under capitalism,"[6] where do we stand with the additional layers of alienation through the neoliberal currents of private EdTech startups pervading public higher education and other civic institutions? In what follows, we offer an ethnographic account of a small group of engineering educators who work against neoliberal manifestations of alienated learning by situating students' technical projects. In the opening vignette, we can begin to connect critical analyses of capitalism, colonialism, racism, and other oppressing -*isms.* The challenge is to situate our own pedagogical practices and the different infrastructures of educational technologies we tend to use in response to these various oppressive -isms.

The presentations we took account of during the virtual conference offered robust contributions of scalable scholarship that address, albeit in a different context, Michael Mascarenas's provocation in "White Space and Dark Matter: Prying Open the Black Box of STS."[7] Reflecting on Sheila Jasanoff's plenary address for "Where has STS Traveled," the forty-year commemoration of the inaugural meeting of the Society for the Social Studies of Science (4S) at Cornell University, Mascarenas encourages us to "interrogate the society's contribution to social policy or enduring social problems... our collective need for reflection and reflexivity... whether, and to what extent, we [are] ready to reflect on the subject matter of race and racism in this

mostly color-blind field of inquiry."[7] What we observed during the ASEE virtual conference were contributions to "Big STS"—a concept introduced by Gary Downey to identify approaches to science and technology studies (STS) that promise broader social impacts beyond the microsociology of laboratory studies, which have long been privileged in the field.

On the surface, this paper is about activisms, social movements, and racial justice in engineering education, but there is an understory about how small and subtle actions, like opening a Slack Channel for crafting, afford alternative virtual maker spaces for different possible futures. How do small, seemingly banal pedagogical practices of "situating engineering education" manifest broader social impacts? In the following, we will curate a collection of ethnographic vignettes that portray the ways engineering educators *situated* their students through online learning, and shifted from the universal and the abstract to engineering practice *in situ*. We are borrowing Jean Lave and Etienne Wenger's concept of "situated learning,"[8] as a way of situating engineering education historically, socially, culturally, politically, environmentally, geographically, locally and globally. We are interested in the very subtle maneuvers in the various ways engineering educators interact and share their online teaching experiences in "the hallways" (Slack Channels) of virtual conference spaces.

In addition to our contribution to the ASEE conference proceeding, this paper adds to a growing body of scholarship in engineering studies, a sub-field of STS, which focuses on engineering education as an important area of historical and anthropological inquiry, and a significant site for interventions of social justice.[9][10][11] This paper aims for a more thorough integration of STS and engineering studies into engineering education research (EER). Through a composite narrative made from a collection of memoirs and ethnographic vignettes, this paper portrays a few marginal experiences in engineering education in the U.S. that were becoming part of a broader phenomenon during the initial impacts of COVID-19 and the forced transition to online learning, which intersected with BLM social movements. Despite social and physical distancing, and the interruption of live, in-person education, we take account of how engineering educators *situated* students' learning experiences through subtle maneuvers in the curriculum. In this way, we contribute to the growing field of EER.

Methodological Background

This paper is a product of an ongoing collaborative NSF EAGER project (DUE-1745922) and early conceptual work (in-progress) on the relationship between educational technology (EdTech) startups and academic institutions through the examination of diverse pathways of lifelong learners, from pre-college to post-graduation and industry onboarding, and the affordances and pitfalls of Massive Online Open Courses (MOOCs) and Small Private Online Courses (SPOCs). The research project began before the impacts of COVID-19, at a workshop at Santa Fe Institute (June 2018) attended by stakeholders from academia, government, and industry invested in lifelong learning in engineering. The workshop aimed to address the general lack of communication between key stakeholders in the ecosystem of engineering education, only to find such fractures and fissures in interaction more deeply entrenched.

We are using the ecosystem metaphor to make sense of the governance of engineering education and the epistemic relationships between institutions and individuals.[13][14][15] The concept of "ecologies of knowledge" can be used to come to terms with the complex sociotechnical

ecosystem of engineering education. In the transdisciplinary field of STS, ecological metaphors have long been used in comparative approaches to epistemology and studies of the co-production of scientific knowledge. The ecological concept affords an openness to epistemological differences, offering a broader, more dynamic, complex, interactional, and relational understanding of diverse forms of knowledge, experience, and expertise. In the intellectual tradition of "symbolic interactionism," the ecological metaphor has been extended to understand institutional ecosystems, metonymically, to link knowledge and institutions by examining the circulation of information. Finally, the ecological analysis also serves as a means of refusing social/natural and social/technical dichotomies, and it can be used to "overcome simpleminded technological determinism or technocracy." We consider the technological infrastructure of engineering education ecosystem analysis as more than a metaphor. The fact that it was a zoonotic disease that disrupted in-person learning experiences and forced education online reminds us about the inseparable relationship between environment, society, science, and technology.

Since the first workshop, we have been conducting semi-structured interviews with selected participants, and their colleagues and collaborators through "snowball sampling" (interlocutor referral). The method of snowball sampling offered a way to map "ecological niches" and "entangled banks."[16] This would not have been possible without the dense (and high profile) associations of key interlocutors we refer to as "keystone social actors." The term *keystone* is a reference to "keystone species" in biology and ecology. The figure of the beaver is often presented as an "ecosystem engineer" to convey the significance of keystone species through the dams they build and how they change the flow and movement of surface waters, thus changing the distribution of diverse forms of life associated with surface water both upstream and downstream from their dams. Our interest in keystone social actors, led to a serendipitous approach to "sampling" that came with a dedication to "saving the 'small N'" of anthropological community studies within EER.[17] This methodological orientation resonates with our general interest in how small actions can bring about big changes in the ecosystem of engineering education. In addition to interviewing, we carried out participant observation through "ethnography of virtual worlds."[18] We applied methods of virtual ethnography in listservs, email correspondences, online conferences, public forums, and webinars.

What is Engineering Education For?

What is engineering for? What are engineers for? These two questions give coherence to the transdisciplinary field of engineering studies; however, the more precise question that moves scholars in the field to action is: *What is engineering education for?* To be sure, the questions are closely related, but the difference is one of analytic scales and a shift from the instrumental practices of engineers to the epistemic practices of engineering educators. Instead of investigating the engineering of technological systems, engineering studies tends to focus on the co-production of engineering knowledge and the disciplinary and professional social formation of engineers and engineering institutions, departments, programs, curricula, and pedagogies. In what follows, we will make this shift in scales of analysis overt and emphasize the significance of the epistemological and pedagogical focus in engineering studies, particularly for scholars whose research and teaching are situated in technical and polytechnic schools of higher education, and scholars who participate (if only marginally) in designing engineering programs and curricula.

The shift in attention from machines to learning is intricately bound together with a focus on educational reform for social responsibility and social justice. Reformers for social responsibility in engineering education have clearly emerged from the fringes of the dominant paradigm of engineering knowledge in every historical era analyzed by scholars of engineering studies. Sustained interventions of social justice can be found in different chronologies and historical periodizations of the major changes in engineering education in the United States. There remains a tension between residual and emergent notions of social responsibility and social justice and the dominance of professionalism and corporate capitalism. This observation synthesizes Edwin Layton's recognition of cultural dominance in bureaucratic "professionalism"[21] and David Noble's recognition of the dominance of "corporate capitalism."[20] In the following contribution to the field, we will underscore the significance of an anthropological and historical focus on the latent and emergent forms of social responsibility and social justice that inhere in the shifting paradigms of engineering education.

A broader definition of "technology" welcomed a human-centered approach to studies of technological systems, which has been paradigmatic for the field of engineering studies. Such a broad definition of technology can be traced back to David Noble's book, *America by Design* (1977), in which he leverages Karl Marx's theory of technological-social change to show how *technology is people themselves*. "For technology is not simply a driving force in human history, it is something in itself human; it is not merely man-made, but made of men."[20] Noble's broader definition of technology opened a pathway from technology studies to engineering studies, placing special focus on engineering education. This marks a shift in analysis from engineers as makers of machinery and forces of material production, to engineers and their social relations as educators, managers, and social reformers, as forces of knowledge production.

Against the epistemic habits that give engineering education a structural and rigid appearance, in this paper, we take account of *engineering educators for change*. Our task is to revisit the notion that engineering educators are agents of academic freedom and social change, albeit committed to industry and not necessarily local communities. It is here that we raise questions about the lingering tensions between social responsibility and professionalism, as an unresolved, continuous moment of political action. Both Layton and Noble write conclusions that put a period at the end of what should remain a question about the tension in engineering (education) between professionalism and social justice, business and ethics, economics and environment, corporations and communities.

In his book *Engineers for Change* (2012), the historian Matthew Wisnioski positions himself in dialogue with Edwin Layton regarding the "ideology of engineering" and Samuel Florman on the transparent failures of technology and the "grim situation" engineers found themselves in by the early 1960s. As weapons systems dictated by the research and curricular agenda of the military-industrial-academic nexus, questions proliferated as to whether engineers were subservient to rather than in control of technological systems. Wisnioski shows how engineers came to view technology as out of control by identifying the socio-technical concerns that mobilized reformers to make their profession honor its social responsibilities. His historical account offers insight into a relatively small group of radical engineers in the United States in the 1960s, as opposed to engineers presumably subsumed by organizational structure. Engineers for change addressed

problems of technology "out of control." Disenchanted with the promises of technological progress, these engineers would have been characterized as dissenters from normative engineering viewpoints. As reformers and radicals, they posed critical theories and different practices of what technology could be. Claiming responsibility as agents of social change, radical engineers offered alternative visions to a mainstream technocratic rationality.

Wisnioski restores the political agency of engineers by amending Langdon Winner's "theory of technological politics," which refers to a perception of the foreclosure of the possibilities of human existence by the encroaching technological systems of modernity. Against an analysis that reduced the agency of engineers and their capacity to control autonomous technology, Wisnioksi recognized that engineers are not just victims of an "ideology of technological change," which presumes human *control* over the unintended by-products inherent in the development of new technologies; engineers are also active participants in technological politics. Wisnioski draws on these two concepts in order to identify themes of out-of-control technology, the uncertainties of possible technological futures, and the political interventions of a marginal group of radical engineers. Radical engineers looked for a more "humane technology" and a more "humane engineering" in what Wisnioski calls a "veritable creativity boom in engineering."[9] Humanist approaches to engineering education have flourished in the beginning of the twenty-first century. For example, Juan Lucena, Jen Schneider, and Jon Leydens have studied and participated in the making of "Humanitarian Engineering" programs of higher education.[11] Also see the Engineering Education Pioneers project at University of Washington.[22]

Building on a tradition of anthropocentric or human-centered approaches in engineering studies that embrace a restoration in the agency of engineers for social responsibility and social justice, analytically and politically, as one possible response to the questions: *What is engineering education for? What is engineering education research for?* Though there are many other ways of approaching these questions, this mode of inquiry and intervention is at the heart of engineering studies, as demonstrated above.

Situating Engineering Education

We began formulating our problem statement after attending a series of online webinars hosted by EdTech companies like Chegg and Course Hero. These companies had become synonymous with cheating among certain university faculty, particularly instructors who taught the same course year after year using the exact same syllabus and course content, as students were apparently able to circulate course materials using these platforms. During one such webinar, the undergraduate research assistant in our research team, Melissa Shuey, took account of a triggering display of professors venting about cheating, and describing students in terms that many would find offensive. The professors' complaints raised further questions about relations of "trust" from a critical pedagogical perspective.

In our ensuing interviews with engineering educators, we realized that others were reacting to faculty discourse of cheating in online exams, and approaching questions of student-faculty relations of trust in nuanced ways. According to one of our interlocutors with chemical engineering degrees:

> I got rid of the final exam and replaced it with a portfolio for thermodynamics. Okay. I've already mentioned, you know, I'm kind of like big into this student agency, open-ended, etc. So I was really upset by how a lot of the discussion about assessment after we went online devolved into spyware like instantly. You know, and it's all about, okay, well, you know, if we pay all this money then some stranger watches them through their computer and might make them show, you know, like what their pants look like and I find that deeply offensive.

Following an "emic" tradition in sociocultural anthropology, we selected responses in conversations about cheating, such as the response described here, to guide the formulation of our research problem. In her own words, we can see how she got rid of the final exam and situated the thermodynamics course in direct response to such problematic educational practices. She described her response to these deeply offensive conversations about cheating and surveillance as follows:

> And so I was like, oh, okay. So in accordance, what I have now is they're all in different places. And so if I asked them, can you find thermodynamics. You know, here are the big three course outcomes. I want you to find those outcomes in place somewhere. And I want you to solve a problem, inspired by what you've found there, you know, and make good assumptions and then, you know, and here's a format, you're going to write a reflection at the end. What you think about this and you're going to do it three times, one for each of the three big outcomes. And it's due at the final exam slot, but you can, you know, you can take three weeks to work on it if you want to, or you can take, you know, three hours to work on it. That's up to you. So I, I liked that a lot. And I think it was kind of unique for the setting... So some people, you know, walk around their house like I had hoped they would or they're setting. And we're like, oh, you know, I've got a refrigerator. I wonder, they're like, we learned how refrigerators work in this class. I'm going to look at the back of the refrigerator and write down all the numbers and see if I can work out from first principles, how much electricity.

Our interlocutor described her educational paradigm of "contextualized" learning and the value of learning *in situ* at a time when abstract problem solving and standardized exams delivered online seemed to be failing at large in engineering education.

> And I think it was a really good. You know they hit the outcomes they demonstrated that. They could solve a complicated problem in the realm of thermodynamics and these three outcome areas and also then we got these bonuses. Oh, I can find some situations that are, to a greater or lesser extent, drawn from real life, but at least they're all messy. Where what I've learned has applied. So I've pitched this to a couple of folks and in fact I tweeted about it and I probably you know like I tweeted the assignments and my video explaining the assignment. I'd ask them messy problem questions all the time...

Such deeply contextual problem solving requires skill. Our interlocutor's notion of "messy problems" were drawn from real life and layered with complexities and idiosyncrasies. Also note, how she circulated the assignment through her Twitter feed, and through a YouTube video she shared with us after the interview. For the purpose of this paper, we want to highlight how

this exceptional engineering educator made subtle changes to her online teaching, under duress of COVID-19, and modified the final exam for the course to a high-context learning situation. In future work we will elaborate how highly contextualized, situated learning can broaden the social impact engineering education for change.

Conclusion

For the conference proceeding, we will only offer this glimpse into the ethnographic data we have compiled on how engineering educators for change situated student learning experiences in an online environment. This is a work in progress. We understand "work in progress" to mean our humble, and short presentation of data and insights will be acceptable. We acknowledge that this is an ambitious project that will require far more research and analysis, which is underway and being carried out collaboratively across the research team. In future work we will further examine the inequitable impacts of COVID-19, issues of white supremacy and anti-Blackness, as well as corporate capitalism and structural injustices. We will examine further how we have located the actions of engineering educators for change as significant. We will also discuss the inseparability of epistemic and social instrumentalities and where the epistemics of the paper itself reside, socially.

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