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Community-Driven, Participatory Engineering Design Frameworks to Shape Just, Liberatory Health Futures

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Abstract

Engineering education regularly overlooks people it is supposed to serve, especially those historically and systemically marginalized by technology. To address this, we must teach students of engineering to engage critically with whom they are designing and work directly with communities living closest to systemic problems. This can be done through community-driven, participatory design where community-based lived experiences inform the development of technical solutions. This work is vital for identifying what problems need technical solutions, and the limitations of technical solutions in addressing systemic challenges. I will investigate what this means in my field of medical technology, rife with racism, sexism, ableism, due to most technologies being developed by those in power, that being white, cis, able-bodied men. I argue that systematically marginalized populations receive worse medical care because of technology and how it was designed. Embedding myself in the narrative through the qualitative method of autoethnography, I detail my own experiences living in a chronically ill body as I experience the severe limitations of current technologies, and how that impacts my own health. Tracing legacies of resistance to dominant systems of power within biomedicine, I uncover the stories of lay experts challenging the existing "politics of knowledge" to democratize biomedical innovation for their own benefits. Weaving together theories of black feminism, queer liberation, disability justice, and embodiment with design justice and participatory design, I outline principles for engineering liberation through health innovation. These five principles include 1) understand the system shaping inequity 2) realize your positioning and power, at the intersections of race, gender, sexual orientation, class, and (dis)ability 3) establish relationships with those closest to health disparities to root out root causes and stay accountable to potential harms 4) build technologies that create value for all parties while remaining "safe to fail" and 5) connect the innovation to a greater political strategy for achieving equity and liberation. This work-in-progress paper ends with a call to action for engineers to choose a side: do we serve as architects of the visions of the powerful, or the visions of the public? As architects of medical technology, our decisions shape who lives and thrives and who suffers and dies.

Introduction

In this paper auto-ethnography is utilized and mobilized as a tool for analysis of the critical gaps that exist in the medical technology space for historically disinvested communities, such people assigned female at birth, LGBTQ+ people, people of color, people that are chronically ill, and people with disabilities. Autoethnography is a research method that mobilizes personal experience to describe and interpret cultural beliefs, practices, and experiences [1]. As Stacy Holman Jones writes, autoethnography is enabled by epiphanies that “prompt us to pause and reflect; they encourage us to explore aspects of our identities, relationships, and communities that, before the incident, we might not have had the occasion or courage to explore.” [1] Before I became chronically ill as a person assigned female at birth, I rarely considered that the decisions that engineers made were as much social and political as they were technical. The decline in my health coincided with a strong desire and motivation to self-reflect and interrogate how engineers shaped medical realities, realities I dealt with every time I entered a clinic and failed to receive a diagnosis or a regime of care. Autoethnography inspires an analysis of the gaps in technology that harm populations, how expertise-driven engineering cultures exacerbate these inequities, and why critical reflection alongside communities with lived experiences of health injustices can improve the way we do engineering - and the health technologies eventually designed.

Whose care? Understanding "unmarked users" in medical technology design

Adoption of new medical technologies is happening at breakneck speed, from decision-making algorithms to electronic health records to personalized medicine [2]. Much of this development occurs under a universalist framework that considers a device made for one patient will likely work for all patients. This is what Constanza-Chock refers to as designing for the "unmarked" user, whose gender, race, class, and age are not specified [3]. Yet in the minds of the engineer, this user likely has a certain set of assumed normal characteristics: English language proficient, with access to broadband internet, literate, with a normally abled body. Because too often the engineers designing medical technologies are of dominant populations, there is often an additional default to craft technologies around the experiences of white, heterosexual (cis)males [4]. Even if additional care is taken to be inclusive of other identities beyond one's own, a default mode of design practice is to craft personas that are meant to be "representative" of lived experiences, yet become stereotypes [5, 6]. A common one used in engineering design classrooms (including my own) are disability simulations where able-bodied people try to experience the lives of disabled persons by temporarily adopting a disability. In this paradigm, designers believe they are developing empathy for those living with the condition and can now imagine ways of "fixing" the perceived problem, but they project a set of solutions that medicalize the condition versus understanding social, cultural, and political forces that shape individual's lives. If these are the paradigms under which we are designing new medical technologies, we must ask: who receives high quality care?

Analyzing a series of regularly experienced medical technologies, I argue from my position as a biomedical engineer, materials scientist, and a chronically ill person that historically marginalized populations are receiving worse care *because* of technology and *how* it has been and continues to be designed.

Suffering from COVID-19? If you are darker-skinned, pulse oximeter devices will be three times less effective in detecting your blood oxygenation [7]. Why is this? Most pulse oximeters were designed and calibrated for white skin tones and completely ignore melanin's attenuation of visual light. What does this mean for your health? Late detection of low blood oxygenation levels can mean a greater risk of severe lung damage and death.

Taking a prescription drug? If you were assigned female at birth (AFAB), it's possible that the drug dosing is too high as only 1/3 of drugs include sex-aware prescribing [8, 9]. Why is this? In pharmacology research and drug development there is ongoing exclusion of female cell lines and animals from preclinical research and historical barring of AFAB people from clinical trials with no follow-up done on original studies. What does this mean for your health? You're more likely to suffer from adverse events that cause negative side effects and even mortality.

Engaging with any medical establishment? If you are Black, there are decision-making algorithms being used ubiquitously in care delivery that might decide that your level of risk to adverse health outcomes is less than white people with the same conditions [10]. Why is this? Algorithms utilizing 1) biased datasets and/or 2) biased model choices work outside of clinician oversight to decide who gets what care. What does this mean for your health? You are bound to get far sicker before you receive the same standard of care.

Taking a diagnostic test? If you are not white, there will be an automatic race-based correction applied to your registered value [11]. Why is this? These formulas were developed by eugenicists who presumed race was biology and thus had an effect on biological functioning while completely ignoring the social and environmental factors of health [11, 12, 13]. What does this mean for your health? The correction might make you look healthier than you are and delay the care you receive.

Experiencing the hospital? If you are intellectually disabled, your healthcare journey likely leads to misdiagnosis and mismanaged conditions and in a crisis like COVID-19 can even be life-threatening as doctors can decide what lives are valuable to save [14, 15]. Why is this? Most healthcare trajectories are designed for able-bodied people and laws are in place that protect doctors who use “stewardship of resources” to give certain lives value over others. What does this mean for your health? Healthcare providers consistently ignore your lived experiences including your symptoms because they do not align with normative structures of the healthcare evaluation.

Visiting your doctor for a routine checkup? If you are physically disabled, in-patient or hospital equipment and architecture might not exist or not be in use. Why is this? Providers might not be able to afford the equipment, might have limited space, or might not know how to use the equipment. What does this mean for your health? You are likely to have a lower standard of care due to your physical disability [16].

All technologies - including medical technologies - have politics that shape the social and political dimensions of healthcare [17]. As Benjamin writes, these ill effects of the technology are not aberrations, but a direct result of discriminatory design that normalizes hierarchies between peoples [18]. In medicine, what is studied is by design, operating according to resources, policies, practices, and priorities controlled by those of the dominant group. They operate under a matrix of domination, a term developed by Black feminist scholar, sociologist, and past president of the American Sociological Association Patricia Hill Collins to refer to race, class, and gender as interlocking systems of oppression [19]. Hill’s paradigm also reinforces a key limitation of many of the technologies analyzed, many of the reports of bias only study one axis of identity. It is likely that if these technologies were reassessed using intersectional benchmarks (if the data even exists) we would find additional architectures of discrimination [20].

The constructed question of whose life deserves adequate care leads also to significant amounts of undone science in medical treatment research or areas of research that are left unfunded, incomplete, or generally ignored despite being of interest to greater society [21]. The systematic non-production in certain areas of medicine is once again a practice of discriminatory design operating under the matrix of domination. Despite affecting 10% of all AFAB people, endometriosis is criminally understudied, leaving many to suffer seven years on average until a diagnosis with no clear treatment paradigm [8]. Pollution-related disease is a growing cause of chronic and deadly illness in communities living at the frontlines of big industry, and yet we have very limited understanding of exposure levels that cause disease and the mechanisms of the disease [22]. Sickle-cell anemia is a debilitatingly painful condition affecting almost 100,000 Americans, but remains unstudied because it is considered a disease that most predominantly affects Black people [23]. We are just now seeing how long-COVID patients are being systematically gaslighted and ignored by providers, in a condition that largely affects middle-aged AFAB people [24, 25].

Technology will only replicate such inequities through artificial intelligence and machine learning algorithms that will "learn" from clinical devices, interactions, and interventions the undervaluation of those without dominant, normative bodies [26]. And it will be done under a paradigm of assuming that data is "real", factual, and objective–these models will use a biased past to predict the futures of care.

<u>Who gets to design medical technologies? Establishing what knowledge counts</u>

Practitioners of medical technologies, including doctors, researchers, engineers of all disciplines, conduct their work in non-diverse working environments siloed away from people living with the conditions they study. Their technical expertise, bestowed by years of training within higher education institutions, enables them to assert their worldview on the field of medicine and medical care. Under the guise of objectivity, medical technology developers can actively replicate white supremacy, heteropatriarchy, capitalism, ableism, settler colonialism, and other forms of structural inequality [27].

And yet, those living with chronic illnesses and disabilities have pushed back against medical expertise to shape research agendas. Notably, queer activists in the 1990s challenged the existing "politics of knowledge", which Epstein defines as how ideas are created, used, and disseminated, around AIDS to democratize biomedicine for their own benefit [28]. This included changing how the FDA regulated new drugs, allowing patients to access investigational treatments that could treat their conditions. Disability justice activists continue to fight to change policy, discourse, design, and practice, ultimately encoding rights to accessibility at multiple levels, including federal policy that governs architecture, public space, software interface design, and medical technologies [29]. Left in the wake of coronavirus, patient advocacy groups are focused on documenting long-COVID symptoms to show the long-term health impacts of coronavirus exposure and fight for better treatment paradigms [30].

These lay experts seek not to just be end-users of medical technology, but also to create knowledge informed by their own lived experiences [31]. Health social movements seek to align patients with a common goal, often a future where their illness or disability experience has validity in the view of the medical establishment. But different health movements have different processes of achieving these aligned goals. Evidence-based movements "acknowledge the importance of scientific and medical collectives, but on the condition that they [lay experts] are considered as legitimate contributors to these collectives' activities and policies…They do neither simply oppose these collectives, nor do they merely become ‘insiders’; rather, they act as *reformers,* with the ultimate goal of shaping the rules of the game differently.” [32]. Under these models of health advocacy there is an imperative to work within current structures, thus relying on those with power to be brought in to give credentialed knowledge. Embodied health movements, in contrast, seek “to address disease, disability or illness experience by challenging science on etiology [the cause], diagnosis, treatment and prevention” [33]. This model is thus inherently adversarial to the current status quo and hierarchies of power. Collective organizing is seen as critical to seeking out treatment, and while those in the system are needed to discover necessary treatments there is a goal of uprooting the status quo. I believe embodied health movements’ focus on systemic change most powerfully resists the matrix of domination and discriminatory design practices, and so will be a focus of later analysis of participatory design strategies.

While patients may not understand the intricate complexities of the science and engineering necessary to create new medical interventions, they know their own bodies. The symptoms they experience are not abstract concepts encoded in jargon, they are real sensations that can discomfort, unsettle, and even disrupt everyday lives. Fields-Spring and Striley argue that our bodies constrict 1) who we are allowed to be, and 2) what we are allowed to do. Our recognition of this allows us to become more attuned as we come to understand ourselves [34]. Knowing your body thus allows you to share how you identify and experience the world, which may differ widely from how you are medicalized in a paradigm that treats you as something to be “fixed” and not someone to be cared for.

As someone living with undiagnosed chronic pain, nausea, and fatigue tied to my menstrual cycle, I have experienced misdirection, gaslighting, and ineffective treatments when I have sought care. There are weeks where I cannot eat due to severe nausea and vertigo, I am bloated to the point I feel unrecognizable in my own body, and severe pain leaves me bedridden. Yet my primary care providers misdiagnose me and delay my care, saying “that sounds like it could be acid reflux, take this medicine and get back to me in two weeks.” When I return in the same condition, they emphasize to me that “pain is a normal part of being a young woman.” When I push back and ask to see a gynecologist, they give me an ultrasound and say everything looks healthy, even when there’s likely endometrial tissue that can be missed on the surface of the organ. The only way to know for sure what’s going on in my body? A laparoscopic surgery, the gold standard of diagnosis for this condition, and a cost- and time-barrier for a graduate student [8]. Thus, I use birth control, a technology that seems to be applied to every health condition afflicting people AFAB, and deal with the emotional physical consequences of hormonal modification. I still am not better.

My proximity to medicine as a materials scientist and biomedical engineer has shown me *why* I cannot get the care I need because *who* has power (white, cis, able-bodies men) shapes *how* knowledge is created in medicine (little to no focus on conditions affecting people AFAB) that then informs *what* is built (limited diagnostics, treatments, and cures for conditions affecting people AFAB).

What does it mean to participate? Defining roles of the ‘patient’

Methods of participatory design and research seek to give non-practitioners living in communities affected by a given problem the ability to engage in the process [35]. It was developed by the Norwegian Industrial Democracy Project, where designers were concerned with the ways that the introduction of new technology in a workplace is often used to eliminate jobs, deskill workers, and otherwise benefit the interests of owners and managers over the interests of workers [36]. Those engaging in participatory design aligned with the following three principles: striving for democracy and democratization, explicit discussions of values, and utilizing conflict to resource design. Ideally, participatory processes endow agency to the public to shape the end outcomes.

In medicine, patient participation and patient-centered care have become increasingly popular goals in healthcare. Patient participation is imagined as "empowerment" of patients to become full partners in their medical decision-making, with a range of interpretations for how patients become empowered, either through top-down authority of a provider or grassroots empowerment and connection with other patients [37]. Patient-centered care seeks to center the patient's problem versus their diagnosis and treat patients like experts, yet this level of participation still requires a doctor to make the final decisions [38]. These unresolved power dynamics mean that many of these participatory design practices remain vague in the roles envisioned for patients [39, 40].

Participation can easily become tokenizing or used to legitimize decisions made by elites and become solely inclusion without actual decision-making power [39]. In our age of digital health, "participation" has often meant the public sharing of personal health data, which has created a goldmine for large corporations who generate enormous profits from the mining, analysis, and commercialization of data [41]. This asymmetry in power turns patients into products, even eventual consumers of targeted goods and services that are not designed to prevent or alleviate their conditions. Even if patients are being "listened to" through their health data, they are still treated by the health system under the medical model of disease, versus considering how greater systems and structural inequities construct health outcomes. Their embodied lives are not given value unless the health data can make a quick buck.

A citizen health model can challenge us to think critically about what healthcare technologies' roles should be. Rather than seeing patients as individuals in need of a technology "fix", they are seen as full actors with agency. Patients are called to engage with their health systemically beyond a biomedical model, embody their conditions and lived experiences, activate around collective responses to illness and empower one another, develop comprehensive care policy, and enable environmental sustainability [42]. Under this model, participation where patients can co-plan, co-create, and co-evaluate new technologies to serve the goals of their communities is essential to creating more just, healthier futures. It requires building with and seeing technology not as an end, but as one part of a greater strategy.

What stops us from building with? Meritocracy, depoliticization, and objectivity in engineering education

Engineering education today is unprepared for the task to realize this community-driven, justice-based patient participation. Far too much of the instruction of engineering focuses solely on the technical, teaching students' how to solve complex math and science problems with singular solutions. This has created generations of engineers who believe if they follow scientific methods of inquiry and design to produce the "best" product the work they have done is objective [43]. This way of thinking incubates solutionism, which Morozov describes as the belief that technology will solve social problems while also defining what counts as technology and who technology should come from [44].

Prioritizing objective inquiry also leads to the phenomenon of depoliticization of engineers, where engineers believe their work can be apolitical because it just focuses on the evidence. It leads to a disconnection from the work of social justice that is inherently heterogeneous, requiring significant collaboration across stakeholder populations and transdisciplinary methodologies of problem solving [45]. In separating themselves from the work of social justice, engineers exclude key variables about society, inequity, politics, and power that are shaping the manifestations of the problems they are trying to address with solely technical interventions.

To fully grapple with power and privilege around race, class, and gender requires bringing narrative and personal experience into the classroom. But, this can be an uphill battle when these dialogues feel incompatible and irrelevant to "scientific" topics like thermodynamics, crystal structures, and circuits [46]. Yet, the fact that these scientific concepts have been used to construct technologies that can then exact harm and embed inequality shows how methodologies of engineering design are inherently value-laden [47]. It is often easier to sell out when faced with the enormous task of structural injustice, because the systems of oppression seek to make it easier to accept less just values [48].

When engineers understand our ability to ask the question "what needs designing?" is political, we realize we must take a side [49]. Do we serve as architects of the visions of the powerful, or the visions of the public? As architects of medical technology, our decisions shape who lives and thrives and who suffers and dies.

Taking a Side: Shaping Just, Liberatory Health Futures

To serve the public good requires a reimagining of how we teach engineering design, transforming it from designing *for* to designing *with*. To design *with* requires an approach that goes beyond surface-level participation where stakeholders are only involved at specific timepoints in the process versus being democratically involved decision-makers [50]. But what might it mean for engineering, a field shaped by meritocracy and thus deeply wedded to expertise begetting power, to be done democratically?

A part of that process is revealing the often-erased engineering solutions existing within designated *"non-technical"* communities. Gomez-Marquz and Young through their Maker Nurse program have re-told the history of nurses as makers and stealth innovators [51]. Working with technologies that were designed without their perspectives, nurses have had to rapidly adapt and solve issues in patient care, from customizing bandages for newborns to making easier-to-open pill bottles. The making process exists as improvisation, readily addressing problems in a practical manner in the best interest of the patient.

Global Open Science Hardware (GOSH) movement also reveals the ingenuity of people outside traditional halls of power, that being academia and big industry firms. One of these events, "The use of the speculum in a practical way – Transfeminist Hard Lab" sought to teach participants how to run a test for HPV using only vinegar [52]. During COVID-19, GOSH organizers worked to reverse-engineer personal protective equipment (PPE) and medical/laboratory equipment as patented models of production left hospital workers short of vital tools. This was something I personally worked on through a rapid-design organization founded in the early days of the pandemic. Community-based environmental monitoring of pollutants can be done with low-cost tools and freely accessible data uploaded onto the internet, allowing communities to track pollutants that might be impacting their health and form a political response.

Finally, intentionally participatory hackathons showcase the ability for technology-oriented spaces to be sites of utopia-building as well as critical engagement with unraveling systems of inequities [53]. During their 2018 event, Make the Breast Pump Not Suck, they created a space grounded in equity that was intentionally inclusive by ensuring that there was time to build relationships before and after the hacking event, as well as ensuring the space itself was one of joy and play. There was an understanding that the technology, a better breast pump, was not the solution (a limitation of their 2014 event where all coverage centered on the fact that MIT was hosting an event around breast pump technology) but needed to be a part of a greater strategy that addressed how breastfeeding is not possible for everyone in the U.S. when there is no universal paid family leave policy. Finally, a focus on making all forms of innovation valid enables everyone to be an engineer and designer, not just those with technical expertise.

Valuing sources of community knowledge is central to the practice of Liberatory Design and Community-Centered Equity Design, practices which call the designer to act as a facilitator of ideas instead of a gatekeeper [54, 55]. Escobar in his book *Design for the Pluriverse* emphasizes the critical need in design spaces to not reproduce Western modernity, and instead create design processes where "many worlds fit", and worldviews, knowledge, and ways of being from Indigenous communities are enabled [56].

Finally, design justice practice calls us to see how domination and ultimately resistance exist at the personal, community, and institutional levels: we must do the work within, to then be able to build community around, to then challenge the existing status quo. We can use design as a process from which change emerges, that seeks to sustain and empower communities as well as liberate us from oppressive systems [57].

To realize design for justice in engineering medical technologies requires methods that understand health in its complexity as an interplay between material resources, healthy environments, communal support, self-actualizing opportunities, and clinical care delivery. Answering Costanza-Chock's call to action in *Design Justice* for critical analysis in every design domain [2], this work outlines the following five principles needed to actualize liberation in healthcare technologies that should be embedded in engineering education: 1) Understand the system shaping inequity; 2) Realize your positioning and power; 3) Establish relationships with those closest to the problem to investigate root causes and assess risks and harms; 4) Seek to build technologies that create value for all parties and are “safe to fail”; 5) Connect the technology to a greater political strategy for achieving equity and liberation.

First, a new design process must be placed in its social and political context. For example, if you were to work *with* visually impaired people, it would be vital to understand things such as accessibility barriers to internet use. Without this understanding, a designer with good intentions designing *for* could design an entire suite of digital tools for “improving” healthcare tracking and see it largely go unused due to inaccessibility. This way of designing also places technologies to an end. The activist engineering paradigm proposed by Karwat challenges us to consider “what is the real problem and does this require an engineering intervention?” [58]. For problems as complex as our health systems, we will need social change that shifts us away from a disease-driven model of health to a more holistic model of wellbeing, and this cannot be coded or machined. As engineers are called now to build and maintain the current sociotechnical order, through critical evaluation they can be a part of building more equitable futures.

Second, the engineer must be prepared to assess how their disciplinary boundaries and lived experiences influences the questions they ask, the information they prioritize, and the ways they approach problems, central to feminist disability theory of universal design [59]. This means challenging universalist frameworks and engaging in a theory of design based in disability justice, collective access, and interdependence that can address the structural conditions of oppression. It is also vital to understand that coming in as a technical expert inherently creates power dynamics due to the supremacy placed upon technical knowledge by greater society [60]. Part of engaging in participatory design involves sharing this power, allowing people to see how technical artifacts are created, and how their own values, hopes, and dreams can be integrated into the final designs [61].

Third, the engineer must establish deep, mutually beneficial relationships with those closest to systemic injustice. Such work of community-building is central to feminist human computer interaction (HCI) and feminist data science practices, which articulate the valuation of ethics and emotion alongside reason as well as the vital importance of standpoint, especially of those at the margins [61, 62]. Its importance is paramount to the design of equitable technical interventions because it enables conversations about what the actual problems are, which then informs the goals of the design (and whether it is even necessary). As I previously discussed, embodying a condition is far different then medicalized models of disease, illness, and disability taught in science and engineering classrooms and understanding the lived experience will uncover unmet needs as well as existing solutions. When in relation with the people they are designing with, the engineer has a responsibility to mitigate risks and harms of a potential project, as impact on a community is considered more important than intent of the designer. This is especially important when working with unregulated technologies like artificial intelligence in medicine [63]. Co-planning before action gives direction to the design and ensures the end goals of equity and justice.

Fourth, technologies are built with stakeholders guiding the features of the end-design and assessed consistently to ensure alignment with co-created plans for mutual value [64]. While stakeholders may not know the ins and outs of the technical aspects of engineering design, their input and ideas can be expressed through low-tech or no-tech prototypes like drawings, paper cut-outs, clay models, workflow sketches, checklists, which were exhibited by participants of all technical skill levels in the Make the Breast Pump Not Suck Hackathon [53]. Often, these low-tech innovations can be viable solutions in and of themselves as they can be made culturally appropriate to existing contexts in ways that no app or sensor could. Part of creating justice in healthcare technology also means rejecting solutionist tendencies and creating space for imagination and future building [65]. Finally, technologies cannot always be assessed scientifically, feminist HCI emphasizes the critical importance of understanding insights that cannot be achieved scientifically [61]. A technology may meet its intended design specs, but if it does so at the expense of the patient's wellbeing, it cannot be considered a sound intervention.

Fifth and finally, the technical solution cannot be the sole solution to a given inequity. Fully realizing the wholeness of individuals requires a holistic approach that shifts policies, practices, and resource flows. If we understand that inequities are products of design, we acknowledge that they can be redesigned to create healthier, sustaining futures [66]. But to do this, engineers must stop passively enabling the status quo that creates stark health inequities and utilize their power to dismantle unjust systems [67]. The role of the engineer must become that of the community-organizer, working to engage critically in a lifetime of work to pursue social justice.

Future Work

These five principles are currently under evaluation through a qualitative interview study exploring these equity-centered, community-engaged engineering design practices and methods for developing new medical technologies and comparing them with traditional engineering design methods. Through engaging with both practitioners and end-users we are examining the benefits and limitations of these methodologies as they relate to designing technologies that can address health equity challenges. These interviews have elucidated 1) current approaches to the design of medical technologies 2) the impacts of these approaches on patient populations and 3) the potential role of community-engaged, participatory design practice to addressing the legacy of harm exacted by biased technologies. We are hypothesizing, as has been expounded upon in this work in progress paper, that building a more equitable future for medicine requires a transdisciplinary, multi-stakeholder design process where problems are addressed systematically with communities. Technology, in this design process, plays the role of uplifting the public's interests when it comes to their health, rather than solving all problems.

We can imagine these principles becoming embedded within the engineering design curriculum, such as first year engineering design practicum or senior design practicum. For instance, rather than delivering engineers a project just in need of building, engineers could play a more active facilitative role in the process of identifying problems that local community members are already working to solve. Additionally, critical reflective processes, like autoethnography, can further elicit design ideas from one's lived experience that motivate action and drive towards the practice of socially just engineering. While momentum is growing amongst individual professors teaching equity-minded engineering as well as entire schools, such as the University of Michigan School of Engineering, committing to an equity-centered curriculum, more work is needed to understand how to transform the engineering discipline to be responsive to the needs of historically underinvested communities. Through works like this calling for exploration of injustices in technology as a part of engineering education - social justice can be made core to the way engineers are trained [68].

Just Futures Come with Collective Action

I dream of futures where not only the care technologies I need are available, but also where my value is not based solely on my ability to produce, where I have clean water to drink and air to breathe, I have communal support, and I am able to work with my community to work towards social justice. Building these futures must be the work of engineers who hold power in shaping sociotechnical realities in medicine. I am taking a side and working to advance the goals of the public. Whose side are you on?

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