

Fatness as an ignored engineering design consideration

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Abstract

In this research and assessment paper, we explore the long-standing phenomenon of overreliance on “average sizes.” This work is motivated by the lack of considerations in appropriate test populations and brings attention to the barriers faced by an overlooked population – people in larger bodies.

Fat studies remain understudied in fields such as engineering design and education; both of which have a unique opportunity to promote body size as a consideration for future designers. We have elected to draw on theories from more studied social identities (e.g. disability) because of the relative lack of theory regarding the unique lived experiences of fat people. The purpose of this paper is to understand and identify the barriers experienced by fat people and how these barriers shape their lived experiences. Our work is guided by the research question: *What are the lived experiences of fat individuals that impact their day-to-day lives as integral stakeholders in the engineering design community?*

To answer this research question, we will be interrogating our own experiences as fat people through the lens of the social model of disability. This model argues that individuals with physical or mental impairments are disabled by society, which subjects these individuals to structural, legislative, and attitudinal barriers and limits their full engagement and inclusion. We used a collaborative autoethnography approach where each author served in the role of a researcher-participant. Grounded in each of our positionalities as fat engineering education scholars and educators but also consumers of engineering design products, we reflected on a set of prompts (collaboratively generated) first individually and then collectively to identify both unique and shared experiences. We conducted a content analysis on these reflections in which we identified the structural, legislative, and attitudinal barriers we have faced. Our findings shed light on the consequences of the lack of discourse around fatness. This includes a discussion on the consequences of underserving this large population by excluding them in the design considerations of the everyday world (e.g. clothes, chairs, airplane seats). The paper concludes with implications for design education.

Keywords: Values Justice & Ethics, Human Centered Design, Collaborative Autoethnography, Fat Studies

Introduction

On January 31, 2000, at 1620:16 hours, the captain of Alaskan Airlines Flight 621 stated, “ok now let’s kick rudder...left rudder, left rudder!” Two seconds later, the first officer replied, “I can’t reach it.” 37 seconds later, the plane impacted the Pacific Ocean [1]. The short stature of the first officer had resulted in their limited access to a crucial control that cost 88 lives in the flight accident. In this paper, we explore whether the cause was the stature of the crewmember, or a long-standing phenomenon of overreliance on “average sizes” - the lack of consideration for

diverse body sizes in engineering design. Motivated by several catastrophic engineering design failures that could have been avoided by using appropriate test populations, we attempt to bring attention to the barriers faced by an overlooked population – people in larger bodies.

As of 2022, 43 percent of adults worldwide are considered overweight according to the World Health Organization [2]. Despite the prevalence of fatness, a neutral descriptor used in this study for people in larger bodies [3], the world is neither designed for nor accepting of fat people. In the US, anti-fat bias is baked into our society [4]. It has origins in systemic oppression and stigmatization of black people, whose body shapes were used as a marker for physical, intellectual, and cultural inferiority [5]. Today, fat people face a miasma of social stigmas such as laziness, a lack of intelligence, gluttony, and ill-health [6-7]. In 2019, Harvard psychologists revealed that 80% of Americans held implicit biases (i.e. internalized, negative perceptions and attitudes [8]) against fat people [9]. Out of the six social-group attributes that were analyzed (e.g. sexual orientation, race, skin tone, age, disability, and body weight), body weight was the only group that has not seen a decrease in implicit bias over the last 13 years [9]. Unsurprisingly, this ubiquitous anti-fat bias manifests as real-world systemic issues faced by fat people across healthcare [10-13], the legal system [14], and the workforce [15-16].

These biases are not only reflected in how fat people are treated (e.g. healthcare professionals spending less time with and listening to fat patients [10, 13]), but also in a lack of consideration in design [17] (e.g. emergency contraceptives only being affective for individuals weighing less than 165 pounds [18]). One of the clearest examples of this in engineering design is marked by the frequently reported relationship between fatness and increased injury/mortality rates in motor vehicle accidents (reviewed in [19]). The Hybrid III crash test dummy, which serves as the US federal standard dummy, is based on the 50th percentile American adult male from the 1970s [20]. This puts anyone who is dissimilar from a 5'9", 172 pound American male [21] (e.g. fat people, women, the elderly) at greater risk for injury or death because their body size, shape, and anatomy was not sufficiently accounted for in the design of vehicle safety measures [20]. The lack of consideration for fat people in design must be remedied to prevent further harm.

While fatness has been studied in fields such as nutrition and sociology, fat studies remain emergent in fields such as engineering design and education; both of which have a unique opportunity to promote body size as a consideration for future designers. The purpose of this paper is to understand and identify the barriers experienced by fat people and how these barriers shape their lived experiences as both consumers of engineering design products and as members of the engineering design education community. We have elected to draw on theories from more studied social identities (e.g. disability) because of the relative lack of theory regarding the unique lived-experiences of fat people in contexts of engineering design. Our work is guided by the research question: *What are the lived experiences of fat individuals that impact their day-to-day lives as integral stakeholders in the engineering design community?*

Theoretical Framework

To answer this research question, we will be exploring the experiences of fat people through the lens of the social model of disability [22-23]. This model, developed by sociologist and disability activist Mark Oliver, argues that individuals with physical or mental impairments are disabled by society, rather than by their medical condition itself. That is, our society subjects these individuals to physical/structural, legislative/policy, and attitudinal barriers which limit their full engagement and inclusion in that society. For the purpose of this work, we are defining *physical/structural barriers* as any impediment originating from the built environment. These barriers particularly arise in the daily lives of fat people (e.g. a lack of comfortable, weight supporting chairs at work or public spaces [24-25]) and in their pursuit of healthcare (e.g. medical imaging systems with insufficient capacity and effectiveness for fat patients [26-27]). As we are focused on engineering design considerations, this barrier will be the primary focus of this paper. However, in addition to physical/structural barriers, we will also be considering legislative/policy and attitudinal barriers faced by fat people. We are defining *legislative or policy barriers* as governmental or organizational systems, or the lack thereof, which negatively impact fat people. For example, while fat people face lower rates of employment and lower wages [11], [28], Michigan and Washington are the only US states which prevent hiring discrimination based on body size [29]. Finally, we define *attitudinal barriers* as interpersonal or cultural factors which negatively affect lives of fat people.

Methods

We used a collaborative autoethnographic approach (CAE) where each author served in the role of a researcher-participant [30]. CAE, an extension of autoethnography, enables multiple researchers to use their own life stories in order to explain how their sociocultural context has shaped their perspectives and behaviors. The collaborative nature of this method allows for an ensemble of researchers to provide their life stories as data and to work together to interpret each other's experiences. In this work, three fat scholars in engineering education engaged in a CAE to reflect on how their fatness shapes their experiences in personal and professional lives. As authors of this work, we first want to acknowledge our positionalities that both motivate and influence the research.

Author positionality

The first author is a PhD candidate in an engineering education (EngEd) department in the northeastern US. She identifies as a fat, white woman. She hopes to spend her career facilitating inclusive learning spaces which produce equity-minded and culturally conscious engineers. She feels that being fat is the most significant factor in how she experiences the world and how she is perceived by others; therefore, she has a particular interest in supporting fat engineering students and normalizing conversations about fatness and body size within engineering design.

The second author is a research scientist in an EngEd department in the northeastern US. She identifies as a fat, international scholar from India. She feels that her experiences in engineering and her identities have made her open-minded and cognizant of how people are different in a lot of ways and that one-for-all systems don't work. Both in her professional and personal life, she has started to adopt a belief that people should have the space and freedom to be their own individuals.

The third author is a tenured professor in an EngEd department located in the midwestern US. She identifies as a short, older, fat white woman. She has been interested in DEI work related to physical access and limitations but had not considered fatness as an attribute to consider until she was approached by the first two authors. She is very aware of how her shortness impacts her experiences with the everyday world which is further exacerbated by her fatness. She brings this perspective to this research by acknowledging that both body size and body shape are important elements to consider when talking about diverse bodies.

Research design

We first collaboratively designed reflection prompts to help guide our data generation; our prompt generation is grounded in each of our positionalities as fat engineering education scholars and educators but also consumers of engineering design products. These prompts were:

- How do your experiences and intersections of your identities shape your work and perspectives as (1) an engineering education scholar; (2) a consumer of the products of engineering?
- What does a day in your life as a fat person look like? Consider the physical/structural, legislative/organizational, and attitudinal aspects of your experiences on a typical workday, in your personal time, and in atypical situations.
- How do you see your experiences as a fat person, or a fat engineering education scholar, as potentially different from others because of your own body size, shape and/or other intersectional identities?
- To what extent do you feel that body size and shape are recognized as critical design considerations in the education and practice of engineers?
- What would you like to see change in the education of engineers or in engineering design considerations that would improve your quality of life?

We first reflected on these prompts individually and recorded our responses independently to avoid social influence from each other. After reflecting individually, we then reflected collectively in a discussion hosted on a web-conferencing platform (Zoom). During this two-hour Zoom call, we reviewed each of our individual reflections, one prompt at a time; expanding on what we had written if necessary. As we reflected on each other's experiences, we also identified insights about how fatness and the intersection of our other identities have shaped our experiences in similar or unique ways from each other. This discussion prompted further

exchange of knowledge and perspectives on the broader issues around fatness and other intersecting identities.

These individual and collective reflections served as data for this study. We used a combined document of our individual reflections, a transcription of our discussion on Zoom, and some real-time memo notes we made during the Zoom call to identify key insights not included in our original written reflections. We then conducted a content analysis on all three data sources to identify relationships between a significant interaction with the design world (e.g., with a design product or experience in the design community), our response to this interaction, and how this response was influenced by or shaped our identity of a fat person. We categorized these relationships using our theoretical framework under the three broader types of barriers. We considered how each barrier impacted us and how we dealt with the effect of the barrier. Organizing our collective experiences under these three barriers also helped us identify other overarching themes in our discussion and reflections, such as how we perceive addressing these barriers as fat scholars. We established reliability in our analysis methods by discussing how the themes related to one another, to the broader literature on fatness, and to the examples of barriers we cited in our reflections.

Summary of reflections from the CAE

This CAE study is grounded in our research question of understanding the lived experiences of fat individuals as stakeholders of engineering design community. To answer this research question, we organized the findings from our individual and collaborative reflections into two major themes: *Theme 1: Perceived barriers*, and *Theme 2: Recommendations for change in engineering design*. Further, we relied on our guiding framework to organize the barriers emerging from our discussions – *Theme 1.1: physical*, *Theme 1.2: legislative*, and *Theme 1.3: attitudinal*. This section is a summary of our reflections and how our shared experiences connect to the extant literature on fatness outside of engineering design spaces.

Theme 1.1: Physical Barriers

As outlined in the framework, we refer to physical barriers as those arising from the built environment. In line with intuition, these barriers were a major focus of our reflections and discussions on how products of engineering designs impacted our life in typical and atypical situations. We further categorize these barriers as those that impact 1) our safety and physical well-being, 2) the cost of living, 3) our quality of life, and 4) our emotional and social well-being. Key examples of these barriers can be found in Figure 1.

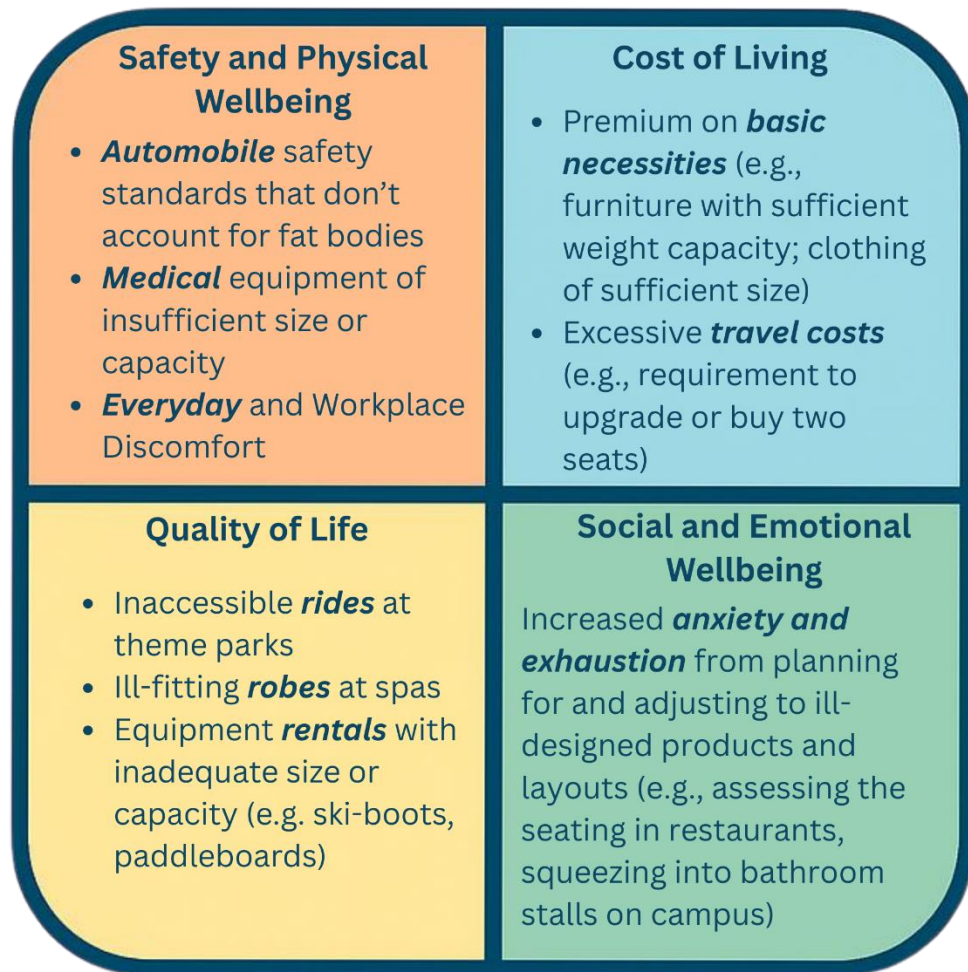


Figure 1: Physical barriers we have experienced as fat people.

Safety and Physical Wellbeing

In recent years, the three of us have become aware of many of the extreme design flaws noted in the literature – particularly those regarding how automobile safety mechanisms [19-20] and medical equipment [26-27] are not designed for fat bodies. For example, the first author shared that she learned in her late 20s that she needed to tuck her seatbelt under her stomach, so that it sits against her pelvic bone; otherwise, she runs the risk of having her organs crushed in an accident. Our conversation around these high-risk design flaws brought up questions about (1) how aware the general population is about these design issues; and (2) what other aspects of our daily life pose a risk to the safety and wellbeing of fat people but have not been considered or studied.

While we touched on some of these more high-risk design flaws, particularly with regard to our anxiety about not being able to receive proper medical treatment in an emergency, we primarily discussed the lower risk, but ubiquitous, physical barriers which arise on a daily basis. We discussed many of the barriers on our university campuses which impacted our lives as students

and instructors. For example, we recalled how the seating in lecture halls is often a tightly packed rows of seats with attached desks. This seating arrangement made it extremely difficult to take notes and exams because the attached desks did not have enough clearance above our laps to sit flat. The second and third authors also recalled how the seating behind the lecture podium, often a tall stool without a footrest, caused experiences of paresthesia and neuropathy. We experience similar levels of discomfort in our lives outside of work (e.g., restaurant seats with arms which dig into our thighs, bathroom stalls that are so small we can barely move).

Cost of Living

The discussion of our lived experiences as fat people brought up several factors that are less represented in the literature – in particular, the premium put on products which accommodate fat bodies. We found in our experiences that most products which are of sufficient size or weight capacity come at a luxury price point, in comparison with their standard counterparts. This applies to products in every part of life, such as: clothing, furniture, bicycles, recreational equipment [31]. In addition to the increased cost associated with everyday necessities, such as clothing and furniture, we also spoke extensively about the excessive cost of travel. Fat people are often either required to purchase a second seat or upgrade on airplanes [32]. As academics, we are often required to travel for work – attending conferences or meeting collaborators. The reimbursement process for travel at our university does not allow us to choose our own seats, let alone purchase a second seat. The third author, a tenured professor, has elected to not attend any conferences she cannot drive to avoid both excessive costs and stress. However, the first two authors, a PhD student and early career faculty member, cannot afford to miss these events at this stage in their careers. This had led to them spending hundreds of dollars out of pocket for the bare minimum of upgrades to allow for comfortable travel.

While we recognize that manufacturing larger products or products with higher weight capacity may incur additional material and production costs, we feel it is essential that some measures are taken to increase the access and affordability of these products. We elaborate on this point in the legislative barriers section later.

Quality of Life

Two of us describe how our experiences with rollercoasters were incredibly traumatic and how the lack of inclusivity in their design limits our access to such experiences. Similarly, outdoor equipment for activities like skiing, snowshoeing, paddleboarding or even hiking is either unavailable or incredibly expensive - limiting them as feasible options for recreation for fat people. Additionally, the inconvenient design of massage tables and the lack of robes of sufficient size in spas, ensures we avoid them for fear of embarrassment. This demonstrates how fat people are limited in their access to experiences that improve quality of life. Furthermore, limitations in considerations of body diversity in design of everyday necessary products, such as seats that dig into the back of our thighs often cause us discomfort, adding to the negative experiences unique to fat people.

Social and Emotional Wellbeing

Our individual reflections and the following collaborative discussions helped us identify that the lack of consideration for body diversity is ubiquitous. A significant theme that became evident was the impact of this lack of consideration on our emotional well-being. We discussed the increased anxiety around everyday activities such as not being able to sit in classrooms or restaurants. In all our independent reflections, we each described how we have developed habits to constantly assess and internally evaluate situations that will keep us from awkward or inaccessible situations such as: trying to get to a work meeting early, so we avoid squeezing past colleagues in tight spaces; or pretending to prefer sitting in an awkward position in classroom chairs (especially ones with attached writing-pads or armrests) that we did not fit in; or avoiding informal social situations completely because we would need to sit on the floor or in a car with 4 other people causing them inconvenience. All of us talked about planning college class schedules, conference session attendances, or meeting times to avoid reaching our destinations out of breath or flustered. This perpetual internal dialogue of adjusting to ill-designed products and layouts so we can “fit in” has a deep impact on our mental health from continued stress, on our self-confidence due to heightened insecurities, and on our access to social support systems because of self-policing. This finding highlights the physical and emotional toll of existing in a world that is not built for us; echoing some of the work done in disability studies which connects the inclusivity of a built environment to individual wellbeing [33-34]

Theme 1.2: Legislative barriers

As our discussion elaborated on and evolved from the physical barriers, our analysis also identified the significance of organizational policies and legislative practices in propagating these physical barriers. For example, we discussed the impact of regulatory practices (or the lack thereof) that allow organizations like airlines and restaurants to prioritize increased revenue in optimizing seating arrangements and discount the resulting discomfort for people in atypical body shapes and sizes including not just fat but also tall people [32]. We highlighted how these practices prove to be exclusionary of communities we belong to and can have effects more pronounced than temporary discomfort. One of us brought up the lack of emergency contraceptives for women over a specific BMI [18] which led to the others realizing how lack of public awareness of this limitation can cause severe harm. The intersections of our other identities with our body size also incited reflections on how governmental regulations on the pricing of consumer products can impact minoritized communities in the form of added costs and taxation of basic necessities like feminine hygiene products that men don't incur [35]. This realization of the intersection of identities further led to identifying the lack of representation of fat people in decision-making communities (both at the design team level and policy change level). We pointed out how practices of affirmative action have played a significant role in influencing conversations about representation with regard to disability, but body size as a category for representation/discrimination remains limited.

Theme 1.3: Attitudinal barriers:

Our long list of barriers brought us to discussions of how we all firmly believed that we experience daily life in a world which was not made for someone of our body type. We referred to how important design considerations omit the needs of the fat community and yet we don't hear a social or professional discourse on this omission. We reflected on how social stigma against fatness has played a critical role in contributing to this silence, both of the people within and outside the fat community. A direct quote from one of our reflections elaborates on how stigma is why we always avoided acknowledging our fatness,

I believe it was because of how much shame and stigma is associated with fatness. We're told by family and doctors and media that fatness is a product of laziness. Any barriers we face as a product of our fatness is our own fault and therefore should not be rewarded by accommodations.

This quote highlights the impact social stigma has on fat people. We are made to and learn to believe it's our fault – a sentiment that was present in all three of our reflections. This internalization of self-blame leads to several long-term consequences such as consistently minimizing our discomfort and never acknowledging them, despite affecting our safety; quality of life; and financial implications. One of us elaborated a personal experience of silently accepting a smaller car from a rental agency and dismissing physical discomfort as a result of our own limitations. This researcher-participant only agreed to ask for a different car after their petite friend expressed discomfort and the inability to deal with it for the entirety of the long journey. She reflected,

I was so ready to suffer, because I'm just so used to squeezing myself into things all the time.

We all accepted how it was our second nature to deal with inconveniences that a thin colleague wouldn't stand for. It was eye-opening for the rest of us when one of us stated in the Zoom meeting:

...that if you are fat, you are worth less than someone that is thin, I feel like is very internalized.

Some other ways we internalize and cope with this self-blame and stigma is by avoiding activities like riding rollercoasters and going clothes-shopping with friends. Two of us also discussed in detail being overly aware of stereotypes that may be associated with fatness such as lack of physical fitness and poor hygiene. They both described how they make extra effort to avoid being perceived with these stereotypes by taking extra steps in their daily life. For instance, one of them pays extra for parking closer to classroom during summer so that students wouldn't associate perspiration with their fatness.

While social stigma influences our internal dialogue and personal habits, it also inhibits us from bringing up fatness in professional settings:

Although I am passionate about body liberation and positivity, I still find myself hesitant to talk with [my peers] about my desire to study fatness.

This hesitance is exaggerated when fatness is treated as a taboo in our professional interactions as seen in the two separate quotes from the Zoom discussion below:

I am always fascinated by the number of people who seem to get really uncomfortable when I refer to myself as fat, right? Like they start to object and I'm like, are you seriously gonna tell me I'm not fat?

...even like now feeling uncomfortable talking about the fact that we're writing this paper with colleagues [who aren't participating in the study] that I feel like aren't gonna get it. Because there were a couple of times even at ASEE. I remember I was telling people about it. And immediately the response was someone laughed like they were like, what? You can't? Why are you saying fat? Why are you using that word?

We discussed the role that societal attitudes and social media messaging play in propagating such taboos. We pointed out how fat jokes in sitcoms are a norm and succeed in re-affirming the implicit bias of fat and non-fat people that fatness is a sign of inferiority. Such taboos impact not only how we interact with ourselves but also inhibit us from enacting the changes we believe we are capable of making in our profession as scholars and educators in the engineering design community.

Theme 2: Recommendations for Change in Engineering Design

Highlighted in our analysis, in part due to the last prompt in the reflection and in part by our discussion on our positionality and intersectionality, the following is a summary list of changes we believe can impact the fat community.

- Discouraging design for the average human: A quote from our written reflection elaborates on this: “*I think engineers are taught to design using the formulaic concept of (average $\pm$ standard deviation) when making decisions on dimensions of their product which excludes a vast section of the population that does not fit in this bracket.*” Another one of us highlighted the need for broader range of adjustments in engineering products (e.g., chairs) which encompasses not just diverse body sizes but also body shapes that do not fit the “typical hourglass” figure.
- Encouraging design for the 5th and 95th percentile of the population: “*My human factors courses in undergrad taught me to design for the 5th and 95th percentiles, because designing for the average excludes most people and experiences. I have very rarely seen that put into practice in my daily life.*”

- Curricular changes for engineering programs: We discussed the impact that inclusions of courses like human factors that promote designing for the majority as opposed to the average would have on the design community and us as consumers of design products. We also discussed the implications of such curricular changes for us as educators in the engineering design community. For instance, we brainstormed ideas on using height, weight, and other anthropometry data [36] to highlight the significance of mean and standard deviations and how representative these numbers are of the populations.
- Representation of diverse bodies in design communities: We discussed how body diversity as a consideration in inclusive practices can empower fat voices in design decisions. We also re-iterated our motivation in identifying and engaging in communities of practice for fat scholars and fat designers.
- Raising awareness for proper etiquette and dialogue on body liberation in professional interactions: While we discussed discouraging taboos around body diversity, we also discussed the implications of microaggressions and how these are normalized differently in different communities. As an example, we pointed out the differences in our personal experiences due to the cultural distance in our upbringing. While one of us grew up always being addressed as fat (the toxic impacts of which were dismissed by labelling it as a mere term of endearment), another grew up where no one ever acknowledged their fatness.

This list shows our perceptions of how validation of body diversity can impact our lives as design consumers. But more importantly, it also shows how our identities as fat people have shaped our attitudes and identities as engineering educators and scholars. This is evident in the ways we envision ourselves as change agents, potentially taking actions towards each bullet in the list and also in our positionalities that describes how our fat experiences have directly or indirectly the directions we pursue in our professional careers. The list above was derived directly from the data in this study, i.e., our collective reflections on how we envision the engineering design community positively impacting its fat members. As a next step beyond this study, we hope to connect these reflections to the extant literature in engineering design education and design a framework for call-to-action in guiding effective practices for body inclusivity in engineering design.

Conclusion

This work started over passing conversations of how our personal experiences have pointed to an observation that current design considerations are never inclusive for diverse bodies. As we found a shared passion for instigating change through our scholarship and roles as educators, we often discussed the importance of broadening perspectives of our students and mentees to accommodate for differences in opinions and experiences of people that they will both serve and work with as designers and engineers. Our experiences as stakeholders of engineering design, who share similar perceptions of the physical, legislative, and attitudinal barriers that impact our lives, helped us identify the significance of appropriate design considerations in product (or

service) development and how design education lacks a deeper discussion of identifying the true population impacted by the design. Using the novel approach of collaborative autoethnography, we were able to recognize shared and unique experiences that impact us as consumers, educators, and scholars of the design community. We identified several different barriers that exist among the fat community including the lack of design considerations in the physical, legislative, and attitudinal spaces of the world we live in. In particular, the pervasiveness, in addition to the high risk, associated with ill-designed products, in combination with the need for more accommodating designs (i.e. 43% of the world population being overweight [2]), reaffirmed our desire to write this call to action to engineering design educators. We reflected on ourselves as members of the engineering design education community and how we would like to enact and see change to improve the lived experiences of our students and colleagues.

This study is the first step in our endeavor to study fatness in engineering design. Our long-term goal is to identify issues of diverse bodies by means of engaging in existing, and creating new communities of practice of fat designers, educators, and scholars of design education. This community of practice will promote effective conversations that acknowledge the existence of diverse bodies in engineering design spaces and eliminate the stigma that propagates barriers for people with diverse bodies to thrive in these spaces. We aim to further transform these conversations into effective educational practices that will help design educators and practitioners include people with diverse bodies as a salient group of stakeholders in the design process. While we are motivated by the specific design consideration of diverse bodies, our work speaks to the larger implications of limiting the categories of information considered during crucial stages in the design process such as stakeholder identification and benchmarking, in turn also pointing to the need for bringing additional perspectives in design education.

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