

# Stories from the Frontline: Recuperating Essential Worker Accounts of AI Integration

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## ABSTRACT

This paper aims to elevate essential worker accounts of the introduction of AI technology amid the COVID-19 pandemic. Drawing from a mix of ethnographic observations, interviews, and participatory design encounters with frontline staff, we examine the experiences of workers in a waste management facility in the United States newly tasked with overseeing autonomous floor cleaning robots. To complement and extend managerial and engineering descriptions emphasizing the functionality and performance of these devices, we used recuperative approaches to re-center the socio-material realities of workers on-the-ground. For example, workers reported concerns on the safety of the devices in congested areas and a need for more comprehensive training across all levels of the organization. This research seeks to expand the discourse on ethical AI by situating essential workers as a key source in developing best practices for deploying new technologies and evaluating pilot projects.

## CCS CONCEPTS

• Human-centered computing; • Human-computer interaction (HCI); Collaborative and social computing;

## KEYWORDS

Invisible work, waste labor, AI, automation, recuperation

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## 1 INTRODUCTION

“[Fixers] know and see different things—indeed, different worlds—than the better-known figures of ‘designer’ or ‘user’.”

—Steven Jackson [23]

At about 6am, before the day shift begins, janitorial staff gather in the break room to greet each other and have their morning coffee before clocking in. They ask about one another’s weekends, families, and children as they wait for their caffeine to kick in.



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Over the morning chatter, shift managers gradually begin to inform their team of updates on each person’s daily routine and what to anticipate regarding late-breaking changes that need to be made. “I can’t tend to the robots all the time! I’m not wearing roller skates,” shouts a staff member as updates are shared. A loud uproar breaks out as several others nod in agreement. Janitorial staff around the room seem to reach a consensus that the “guessing game” of where the recently deployed floor cleaning robots might be and how they might be performing disrupts their daily work. One staff member rolled their eyes exclaiming “ten more minutes, it adds ten more minutes [to my routine]!”

This morning scene illustrates a moment of fellowship and shared commiseration common among janitorial staffers at an airport in the Rust Belt region of the United States. It is here where we spent the last 20 months studying the rapid deployment of AI technologies in response to the COVID-19 pandemic. Specifically, we focused our attention on the Airport’s pilot of autonomous floor cleaning robots outfitted with ultraviolet (UV) light, deployed as a chemical-free means of disinfecting its over half a million, heavily trafficked square feet. After social distancing mandates went into effect in the United States at the beginning of 2020, the Airport forged a partnership with Northfield Robotics<sup>1</sup> who provided them with four robots at no cost. In exchange, Northfield Robotics leverages the expansive and diverse terrain of the Airport as a testing site, in order to push early versions of their software or introduce hardware add-ons for refinement before wide release to the market. Through this arrangement, the Airport became one of the first in the field of cargo and airplane travel to apply UV technology in the wake of the COVID-19 pandemic. Though a powerful tool, the UV robots were not able to act on their own, requiring careful calibration and coordination on the part of janitorial staff and Airport management.

Scholarship within the field of HCI has long considered the importance of maintenance and repair practices necessary to sustain the technical systems upon which workplaces come to rely [23, 29, 36]. Studying copy machine repair, Julian Orr illustrates the social nature of such expertise. Describing the importance of occupational community, he refers to “war stories” told in detail by technicians as a means of establishing social connection and collaborative diagnosis—like the scene that opened this paper. The work of managing and tending to disrepair, that which involves “filling gaps, holes, and cracks,” requires knowing and seeing the world differently than the more prominent figures of the ‘designer’ or ‘user’ [23, 28, 39]. “Repair-thinking” epistemology, as Steve Jackson refers to it, requires regular adaptation and improvisation as it

<sup>1</sup> All organizations and individuals’ names have changed to preserve anonymity.

is deeply contingent and reliant on the tools and standards within a particular context [23].

Building on this critical tradition recognizing the centrality (and invisibility) of maintenance, this paper examines the transformation of essential work at the Airport as janitorial staff support the deployment of AI technologies during the pandemic. Drawing on ethnographic observations, interviews, and participatory engagements over a nearly two-year period, we extend managerial and engineering descriptions emphasizing the functionality and performance of the autonomous floor cleaning robots. We use recuperative approaches to re-center the socio-material realities of workers on-the-ground [32] who report concerns on the safety of the devices in congested areas and a need for more comprehensive training across all levels of the organization.

This research offers two core contributions to the HCI community. First, we present this case as a means to elevate the perspectives of essential workers in waste management and their role in managing emergent technologies, threading together multiple forms of storytelling to illustrate individual and collective experiences of tech integration within a complex organization. In bringing forth these accounts, we not only seek to celebrate frontline workers' contributions to technical implementation, but also—in the words of Lucy Suchman—"call into question the grounds on which different forms of work are differentially rewarded, both symbolically and materially" [36]. Second, we confront ritualistic tendencies in how participatory design is applied by making room for adaptability, re-framing, and customization. In using recuperation as a lens, we position essential workers as experts with the capability to spotlight overlooked problems in systems design and imagine a new set of integration strategies rooted in their knowledge and experience. In bringing forward these contributions, we argue for expanding the discourse on ethical AI by situating essential workers as a key source in developing best practices for deploying new technologies and evaluating pilot projects.

In the paper that follows, we begin by offering an overview of the organizational structure of our field site, and briefly describe a set of literature that informs our perspective on the invisible work of AI and alternative narratives surrounding innovation. We then describe our methods and turn to a set of vignettes that draw out janitorial perspectives on the deployment of autonomous UV floor cleaning robots at the Airport, contrasting them with more dominant administrative accounts. We end by discussing the ways in which ethnographic and participatory practices can design the conditions for workers to convey the stakes of their labor through deliberate de-centering of the designer and user, and active re-centering of essential workers.

## 2 BACKGROUND

In this section, we contextualize our research on the changing shape of waste labor brought on by the expedited deployment of automated technologies in response to the COVID-19 pandemic. We speak to the history of our site and its organizational structure, including the nature of janitorial work at the Airport, to set the scene for the empirical accounts that follow.

Though widespread deinstitutionalization and disinvestment from the region marked the late stages of the last century and led many large airlines to move their hubs elsewhere, the Airport has

seen a jump in passengers throughout the 2010s (largely due to an influx of startups and the growth of the region's healthcare industry). Presently, the Airport is undergoing an expansive renovation to become the first in its field, globally, to be completely solar powered through its own microgrid. With this renaissance in recent years, the current CEO cemented revitalization efforts by stating that the long-term aim is to become the "smartest airport in the world." In line with this bold vision, the Airport was the first to deploy UV technology in the wake of the COVID-19 pandemic through a partnership with Northfield Robotics.

The Airport is managed by the County Authority who makes executive decisions and sets organizational priorities. For instance, daily activity data are sent to the County Authority in addition to Airport administrators. The cleaning staff—the lead manager, shift managers, and janitorial staff—are all employed by an international cleaning and facilities management firm, Building Facilities Management (BFM), who holds a longstanding contract with the Airport. The lead manager is a BFM representative who supervises the work of both shift managers and janitorial staff, and shift managers directly oversee the janitorial workers assigned to their shifts. There are three shifts—day, afternoon, and night; each with their own set of shift managers and janitorial staff assigned to them. Members of the day shift, for example, arrive around 6am, promptly begin their shift at 6:30am, and clock out at 2:30pm. During each 8-hour shift, janitorial workers are expected to complete four rounds of their assigned route, which can differ week-by-week and, at times, day-by-day.

With the onset of the COVID-19 pandemic, the vast majority of janitorial staff were furloughed. Roughly ten remained (out of the original 79) to support the Airport's operations during the early stages of viral spread, but whole concourses were blocked off to reduce necessary daily cleaning. Those who stayed were the first to be introduced to the floor scrubbing robots when they were deployed in March 2020. Though re-hiring has since commenced, the process is staggered, and the Airport has yet to reach pre-pandemic levels in terms of frontline support. According to the janitorial staff in place now, they have each taken on roughly 2-3 additional tasks to make up for the work left undone by their missing colleagues and brought on by the introduction of the robots.

## 3 RELATED WORK

In the following section, we outline scholarship that motivates and animates our research. First, we discuss research on the human work undergirding AI, from content moderation that quietly ensures our social media platforms are free of violent imagery to "micro-work" that provides data for algorithms powering the AI-driven technologies that we are now reliant on. We then draw on the notion of everyday design, as well as work that seeks to elevate this activity as inventive. Finally, we discuss research that critically examines the use of counter-narrative strategies to push back on popular depictions of innovation that render efforts of integration and maintenance invisible.

### 3.1 The Invisible Work of AI

HCI scholarship has long cast a critical eye on technological change taking place in workplace environments with a focus on how such shifts affect working conditions [13, 34, 36]. While the outcomes

of tech interventions in the workplace may be visible and tangible, the individuals tasked with ensuring that systems function as they should often remain behind the scenes—or carrying out, what Star, Suchman, and other feminist scholars would refer to as, “invisible labor” [16, 34, 36]. Highlighting the integral nature of this work, Suchman argues that the limits or parameters that currently structure working relations are not “discrete phases in some ‘system life cycle,’ but complex, densely structured courses of work without clearly distinguishable boundaries between” [35], realized through institutionalized arrangements and practices of configuration, redesign, and maintenance. Though not well understood or publicized outside of organizations, Orr speaks to workers’ inclination to disseminate this configurational knowledge amongst themselves through “war stories,” where they might circulate accounts of how they previously rectified or addressed unresolved issues — exchanging shared expertise and highlighting the social nature of repair.

Over the last decade, the field’s attention has turned to examining the overlooked labor that sustains AI systems [2, 16, 21, 31]. Gray and Suri [16] describe how the push for technological advancement intensifies human labor under the guise of automation. Content moderation on large-scale social media platforms, for example, depends on human processes of tagging, rating, and reviewing violent and offensive imagery. Yet, the contract workers often doing this labor are cast away in separate facilities and offered much less impressive pay and benefits than their design and engineering counterparts. Irani refers to this as “hidden layers of human data work” [21], accounting for the accumulation of labor from those not properly compensated nor acknowledged [37]. Wolf similarly argues that, though AI is often referred to as a driver for automation and displacement, integrating such systems in practice requires considerable human effort “to conceive of, train/test, deploy, and ongoingly maintain” [41].

Researchers have recently taken the lens of invisible work as a design focus to consider how undervalued practices within organizations might be made newly visible [22, 24, 25]. For example, Kow and Cheng [27] describe the development of an open work review system designed to identify and celebrate hidden human contributions within the context of an air cargo handling company. Others argue for the need to design tools that explicitly support the work of maintainers who are essential to the uptake of a technology within the settings in which they are deployed [38]. More recent HCI scholarship highlights healthcare workers’ stop-gap efforts to integrate 3D printing technologies into their work practices out of a sense of moral responsibility amid the pandemic, developing local solutions to supply chain failures preventing access to PPE [46]. These care providers performed the social and technological repair work necessary to affect relief efforts via material alternatives and workarounds, as well as adaptation work to fit to local standards and needs [47]. Such attention upholding an ethos of safety, reliability, and care (despite extraordinary constraints) marked essential work broadly at the beginning stages of the pandemic, and reignites a need for us as design researchers to focus infrastructure design with a commitment to reduce harm — for, as Lakshmi et

al. note, “intermediaries bear the disproportionate cost for infrastructure creation and maintenance” [46]. Here, we build on and extend this work to both recognize the inextricable nature of human work required to make AI function and call for new strategies of design and deployment to incorporate the voices of those who do this labor.

### 3.2 Recuperating Everyday Design Practices

Attention to mundane and everyday invention highlights the ways in which technological infrastructures are altered and modified through forms of use [5, 14, 40]. Wakkery and Maestri argue that the domestic household brings forth design sensibilities, with family members modifying their residential spaces so that the technology they acquire can meet their particular needs and allow them to function under ongoing daily pressures they may face [40]. This is perceived as creativity performed in the intimate context of the home; however, these efforts are often only comprehended by the individuals creating and living with such designs [5, 10].

Recognizing the importance of everyday practices of design outside the home, researchers have used participatory methods to engage community members and other stakeholders toward more appropriate and sustainable solutions [4, 7, 11, 12]. Common among these methods is collective futuring, moving from incremental adjustments within one’s environment to imagining preferable and lasting outcomes [9, 17, 19, 20]. Heitlinger et al. [19], for example, describe efforts to elicit the realities of urban food growing and construct alternative visions for smart futures in collaboration with grassroots community groups in Newcastle upon Tyne. Through the application of participatory methods, the authors contrast the top-down, technocentric visions of smart cities to the priorities of grassroots communities confronted with the consequences of austerity. Similarly, Harrington and Dillahunt [17] describe the application of design fiction to envision a collective future through the lens of youth enrolled in a Chicago-based design summer program. Through attempts to conjure a utopic reality, the youth continue to ground their futuring in present-day social and political forces by articulating design fictions that are, still, heavily laden with dystopian everyday realities of racism and poverty. Each underscore the necessity of participatory methods to unveil preferable and sustainable outcomes while also revealing the need to expand beyond the limitations of dominant speculative practices.

Contrasting dominant, linear visions with practice, methods of critical fabulations offer a lens through which to engage everyday design narratives silenced or forgotten within the wider discourse [32]. As Rosner describes, strategies of recuperation seek to “revive stories enmeshed within a current design setting but suppressed by prevailing design narratives” [ibid]. Attuning to stories unseen and unheard, Rosner calls on design researchers to ask, “what stories are not being told” [ibid]. Not simply a matter of recognition, attending to those unacknowledged within the disciplinary parameters of design yet actively contribute to its outcomes allows for opportunities to question and reconfigure dominant visions of innovation and bring about responsive action. With our own work, we seek to

build upon epistemological intervention by unveiling the realities of essential workers' circumstances as they carry out the human labor critical to producing and maintaining technological systems — AI technologies deployed in the shadow of the pandemic — as well as put forward recommendations for their organizational futures.

## 4 METHODOLOGY

To bring the daily work of janitorial staff to the fore, we draw upon feminist technoscience perspectives foregrounding the notion that “the perception of any situation is always a matter of an embodied, located subject and their geographically and historically specific perspective” [3]. We consider recent critiques on traditional participatory design (PD) methods with focused attention on design workshops as they are currently practiced. HCI scholars argue that despite its founding principle of democratic participation—rooted in the politics of the Scandinavian labor movement—participatory design methods are often carried out as a “privileged, White, youthful, and upper to middle-class approach to innovation” that “reveal taken-for-granted expectations, priorities, and ideals” [18]. For instance, Harrington et al. note activities that prompt participants to consider idyllic conditions from which to generate ideas exacerbate social inequities, leading to the development of “infeasible solutions that ultimately frustrate underserved individuals” [ibid]. Extending this critique, Rosner et al. call attention to design workshop methods as a “living experiment,” encouraging an artful approach to their development and execution toward “expanding the reach of its investigative imagination to new formulations of research practice” [33].

Informed by these perspectives, we center the vantage point of workers within the complex institutional context of the Airport. We turn to HCI scholarship on recuperation, examining whose stories underpin design by elevating the lived experiences that have been suppressed in design settings to inform lines of inquiry [32]. Our work is also informed by recent calls to reexamine our field's reliance on empathetic strategies that tend to be extractive, and position designers as responsible for attuning to the asymmetries that inform design and innovation practice [6].

From this critical orientation, we developed a set of bespoke processes that piece facets of existing design research methods such as visual prompts, qualitative interviews, participant observation, and participatory design, while taking into account the circumstances of janitorial staff's material constraints — namely, the limited time and capacity available due to the increased responsibilities brought about and cemented by the ongoing pandemic and their status as essential workers. In doing so, we address two key questions: 1) *How is frontline work reshaped by the rapid deployment of AI amid the COVID-19 pandemic?* and 2) *How might worker-centered inquiry inform an organization's protocols and policies around technology deployment?*

Our team conducted ethnographic observation at the Airport over the course of 20 months, from June 2020 until February 2022 under IRB approval. When we began field research we established pandemic-specific observational protocols, including social distancing, protective equipment, and the keeping of detailed interaction logs should contact tracing be necessary. Our field visits were

guided by an attention to the tasks performed by workers, the “pain points” that emerge through their interactions with technology and the solutions enacted by workers and managers to overcome them. We conducted informal conversations with workers throughout our site visits. During field visits, we shadowed the lead manager and shift supervisors for 2- to 4-hour intervals as they went about their daily duties and managed the ongoing work of supervising janitorial staff and maintaining the newly deployed autonomous floor cleaning robots.

Extending our observations, our team conducted qualitative interviews with Airport staff (including administrators, public relations personnel, and managerial staff), and engineers and field technicians from Northfield Robotics. Collectively, these methods helped us develop a robust understanding of the attitudes toward and intentions for the automation of essential work in response to a global public health crisis within the context of the Airport. However, we found that the experiences of janitorial staff who work directly with the UV floor cleaning robots remained absent or partial, sustaining a narrative that centered the vantage point of administrators and managerial staff and omitting the insights on the socio-material daily realities that encompassed the implementation process.

### 4.1 Participatory Workshops

To begin to address these absences, we conducted two participatory engagements with sixteen janitorial staff over the span of two days. Each took place during a thirty-minute window as janitorial staff prepared for their early morning shifts, allowing us to have private, concentrated conversations. Through coordination with the lead manager, we were offered a large storage room in close proximity to the cleaning staff's main space yet separate from their break room which was within earshot of the managers' offices. We set up the room with a 6-foot-long fold-out table and chairs and laid out visual prompts for staff to review as they walked in. Each morning, the cadence of the conversation and group formation developed organically making room for individual commentary, group discussion, and airing of grievances.

Our visual prompts were inspired by scenes from our fieldwork and mimicked the format of storyboards with an unfinished aesthetic to spark resonance and personal reflections on the illustrated phenomenon [26]. We selected four scenes to represent particular moments in a janitorial staff member's daily routine reflecting their decision-making processes and attitudes, often along points of tension between implicit expectations, day-to-day work, and administrative directives. Themes that connected the four illustrations together were internal communication patterns, use of time, and forms of deliberation. Specifically, the illustrations included: (1) a vignette of the way a janitorial staff member was introduced to the robots and instructed to respond to water spillage or technical malfunction, highlighting the frequency of these encounters, (2) a story depicting varied reactions to an urgent radio call from management, with four janitorial staff members being pulled away from their current tasks to respond, (3) a portrait of a staff member receiving a radio call with thought bubbles left blank to be filled in, and (4) distinct ways staff have altered the robot's hardware, such



**Figure 1:** Image of a comic strip used as a visual prompt during a participatory engagement with janitorial staff. The title is *Trial and Error*. It illustrates the steps a frontline staff member takes as they try to fix a robot that stopped working. After emptying the water tank and de-installing the scrubbers, the robot is able to apply its UV disinfection without the tools that pick up the dirt and soot off the floors.

as de-installing the scrubbers attached to the robot or emptying the robot’s water tank, so that the robot could travel through the complicated terrain of the Airport to avoid further malfunction and preserve the use of the UV light.

## 4.2 Ride-Alongs

To further contextualize conversations from our workshop, we also engaged in extended observations—what we term “ride-alongs”—with staff, to experience different aspects of the ongoing work of integration. Ride-alongs entailed following staff as they loaded their carts, communicated and socialized with colleagues, conducted routine check-ins, and maintained the floor cleaning robots, in addition to other day-to-day aspects of their work. The half-day ride-alongs aimed to conduct further contextual inquiry while providing the research team with access to the Airport, beyond the TSA checkpoint, for several hours at a time with staff supervision at all times. Each provided further depth to the full scope of experiences varying team members may endure and experience on both sides of the Airport—“air side” and “landside”.

We conducted two ride-alongs with two staff members, each spanning four and a half hours. One was a seasoned employee with 15+ years of experience with the company, and the other was new to her role, though not to airport procedural care and management. Through direct coordination with each staff member, we were able to meet with each individual at the start of each shift allowing us to spend the morning from two different vantage points and styles of work. The ride-alongs provided insight into the daily maintenance of the UV floor scrubbing robots, from placing them on the floor, cleaning the hardware, rebooting a malfunctioning robot, to returning them into their storage unit.

## 4.3 Data Collection

Through the lens of recuperation, we took note of data through both traditional and in-the-moment means. This approach accounted

for the proliferation of conversations that developed during our participatory workshops—from formal responses to sidebar chats—to capturing information at a moment’s notice during immersive ethnographic engagements.

*Field notes* allowed us to illustrate the contexts in which janitorial staff expressed in their personal accounts of specific circumstances and further situate their lived experience in relation to the greater ecosystem of the Airport. Handwritten jottings and audio recordings captured immediate observations and quotes kept in context. Data was then produced in the form of ethnographic fieldnotes which recorded the everyday work practices of waste laborers and their perspectives on contending with automated machinery on the ground [48]. This field data provided a more complete picture of workplace practices, allowing us to witness activities that occur, even those that may not seem important to participants or worth reporting in formal interviews [49].

*Visual prompts* provided a reference to the individuals who were a part of our conversations in addition to the visual cues that sparked our conversation. This tool allowed us to point to what the conversations entailed and who specifically was stating what, and in response to whom.

*Video footage and photography* captured the technology in its habitat. This tool allowed us to capture the UV floor scrubbing robots in action (or inaction) providing visual reference to further chart the relationship between the technology and its material environment.

## 4.4 Data Analysis

We analyzed our data thematically using inductive techniques of contextualized grounded theory until a confluence of themes began to emerge [8]. This approach allowed us to foreground the socio-material realities of deployment from the vantage point of janitorial staff. We developed reflexive memos based on our field notes and other empirical materials and reviewed them together





**Figure 2: Image of a floor scrubbing robot in the conference room where our participatory engagements took place. A green light illuminates the room indicating that the robot is ready for use.**



**Figure 3: Image of a floor scrubbing robot with a flashing red light, indicating that it is not currently working. It is stalled out facing one of the exits of the Airport in the baggage claim area.**

during weekly meetings. Mapping our insights, we began to illustrate internal processes and (informal and formal) organizational structures that shape how the UV floor scrubbing robots perform at the Airport. We then iteratively revisited and refined our interpretations across later rounds of analysis, building emergent foci such as diagnosis of robot errors and duties of care.

Analysis of the data from our workshops and ride-alongs was further informed by complementary research projects, including an extensive investigation of news reports covering the deployment of AI in our respective industries during the 5-years preceding the Covid-19 pandemic [42] and a set of interviews conducted with

engineers, designers and researchers working in the space of service robotics, as well as economists analyzing the COVID-19 pandemic’s impact on essential work.

## 5 FINDINGS

In this section, we bring the lived experiences of janitorial staff to the fore by weaving their stories—surfaced through ethnographic observation, interviews, and participatory engagements—together to paint a vivid picture of the deployment of floor cleaning robots. By recuperating their firsthand accounts, we position janitorial staff as central sources, contrasting administrative decisions made to steward the deployment process with the day-to-day realities of integration. We thread each series of vignettes to form a collective reflection on essential workers’ critical role in safeguarding the public at the Airport by bridging a widening gap between organizational protocols for maintaining automated technology and said technology’s malfunctions.

### 5.1 Diagnosing Malfunctions

**5.1.1 Janitorial perspectives.** Skepticism and suspicion were underlying themes throughout our participatory engagements as janitorial staff diagnosed the AI-powered robots as a technology that required static and low trafficked environments to function properly. They questioned the Airport administrators’ — or as some referred to them as “airport dignitaries” — motives for deploying the floor scrubbing robots due to their inability to effectively handle the Airport’s unpredictable environment. Doubt rose amongst janitorial staff as the pilot for the floor scrubbing robots reached its two-year anniversary. Each day, they reported seeing recurring kick-outs—abrupt halts, water spills, and sudden, quick movements in place—due to a range of interferences including travelers walking close to the robots or technical issues brought on by things like new signage that impeded the robots from following their original, mapped path. Such issues led staff to the conclusion that there was a misalignment between the floor cleaning robots and the Airport’s ever-changing setting.

Janitorial staff often saw passengers jump in front of the AI-powered robots as some attempted to ride the roughly three foot by four-foot machines causing the robots to abruptly stop or jolt in place. “[The AI-powered robots] have a bad habit of whenever there’s people going on both sides of them, they get into this thing where they start jerking back and forth and may continue to jerk back and forth even after all the people have gone,” illustrated Margaret, a janitorial staff member, as she deduced from her frequent, daily encounters with the robots that they were not intended for high-traffic spaces like an airport. She likened their reactions to unpredictability and human interference to the sudden loss of control of one’s vehicle on the road—“like if your car was shimmy-ing. If you had bad tires or something and your front end was shimmy-ing, that’s what [the AI-powered robots] do.” Barbara—another member of the janitorial team—brought our attention to the robots’ tendency to spill water when grinding to a halt, making clear that “it’s not little dribbles.” She inferred that it was indicative of a larger mismatch between the robot design and the Airport. Barbara expressed that “if they moved and restarted like they’re supposed to, I [wouldn’t] have a problem with [them].” However, “when it stops, it’s done.”

The types of malfunctions that the robots experienced was seen by staff as a fundamental misunderstanding on the material and social dynamics of the Airport, leading many janitorial staff to the conclusion that placing them on the floor during the day shift was “just for show” so that the robots were visible to the general public.

**5.1.2 Administrative viewpoints.** In line with janitorial staff’s diagnosis that the robots were not made for complex environments such as the Airport, the framework used to design the floor scrubbing robots indicates a need for a low trafficked area for the robot to function. Northfield Robotics—the company that developed the system—shared that the floor cleaning robots followed a theoretical “co-bot model”, where the emphasis was on an employee and robot co-worker cooperative system in that the “robot fits into their routines and takes work away from them.” The lead shift manager and one of the Airport administrators framed this as “augmenting existing work” as they forge a connection between the floor scrubbing robots and the night shift’s cleaning efforts. For instance, the night shift polishes the floors “during a period of time when no one else is in the building, or very few people [are around] to get optimal results.” Immediately following this thorough cleaning, the day shift places the robots on the floor to “augment our overnight cleaning services.” However, the “co-bot model” does not work well in settings that are contingent on multiple factors including unpredictable human behavior, as is the case with busy travelers rushing to baggage claim or the next concourse. In this case, the robot acts, in essence, separate from its “co-worker” and deviates from their “co-worker’s routine,” fracturing the “co-bot model.” Though the lead shift manager stated that the intention for placing the floor scrubbing robots out during the day shift was to “augment existing work,” the decision to keep them during this time period was ultimately made by airport administrators, as stated by two shift managers. This choice further underscores a statement made by the Airport’s marketing team on the organization’s two-pronged, long term vision. The first goal was to become “a global leader in aviation” by experimenting with novel innovations to “set the curve” for their competitors. The second was focused on signaling to passengers that it was safe to travel through the introduction of state-of-the-art technologies. As airlines gradually resumed to schedule more flights, airport administrators continued to mandate that the robots be kept on the floor during the day shift despite the rise in foot traffic. The discrepancies between efficiency directives, Northfield Robotics’ intentions, and the AI-powered technology’s capabilities deepened janitorial staff’s diagnosis of misalignment.

## 5.2 The Capacity and Authority to Oversee the Robots

**5.2.1 Janitorial perspectives.** From our empirical engagements, we found janitorial staff desired a range of ways to regain a sense of autonomy in their roles, given that each had taken on additional tasks due to the pandemic. Scott, a janitorial staff member who had spent approximately five years at the Airport, was part of a group of ten individuals who were the first of the cleaning staff to be introduced to heightened sanitation protocols and use of the autonomous UV floor cleaning robots in response to the onset of the pandemic. Though Scott was present for a demonstration of the technology led by a representative from Northfield Robotics, he



**Figure 4: Image of a staff member cleaning the filter and refilling the tank of a floor scrubbing robot.**

pulled one of the authors aside during a participatory engagement to share that he wished to be formally trained on how to use the robots. He believed this training would allow him to bypass the redundancies that he observed through his current line of work. He stated that the process of radio-ing his shift supervisors each time he caught one of the robots malfunctioning or being called to clean up after the robots without warning didn’t seem like an efficient way to operate as it created additional work. Scott was perplexed as to why he and his peers weren’t provided with the opportunity to be trained. As he saw it, the current process created an informal system dependent on one to two shift managers who had been selected to receive dedicated training, but were weighed down with other, more distant duties.

Scott’s frustration and confusion were not isolated feelings; the sentiment across the cleaning staff in both of our workshops was a sense of resignation and irritation on the current method of addressing malfunctioning robots. However, rather than wanting to take on additional work, four janitorial staff members expressed a wish for an app that enabled members of the cleaning staff to redirect a robot’s route to where it is most needed (rather than the set course it currently followed). For instance, if a passenger notified airport staff of a nearby coffee spill, janitorial staff could use the app to send the robot to the appropriate location to clean up the spill immediately. Alternatively, they suggested hiring one individual whose job was fully dedicated to the maintenance, tracking, and management of the fleet of floor cleaning robots. Janitorial staff had previously assumed this would be the role of the technician from Northfield Robotics, yet it turned out not to be so. They stated that if one person was dedicated to this role, then it would release the additional cognitive load that members of the day shift currently carry in monitoring the devices from afar (and on top of their other responsibilities).

**5.2.2 Administrative viewpoints.** From our ride-alongs, we found janitorial staff’s limited access to training in the maintenance of the floor scrubbing robots was due to a hierarchical selection process. Rafael, the cleaning staff’s lead manager, referred to his shift

managers as the “everyday coaches” implicitly stating that they are tasked with the responsibility of equipping janitorial staff with the training appropriate to their scope of work. Rafael believed that he is the “theory” and his supervisors are the “practice” or the application of BFM’s approach to facilities maintenance. Similarly, while airport administrators acknowledge that frontline workers “buy-in into the technique or the strategy” of technology deployment is pivotal to its success, they did not directly shape how training was determined.

Antoni—a senior shift manager who received the most training in the floor scrubbing robots and has a background in mechanical engineering—was placed at the helm of determining protocol on ways to train employees on the new technology. From our observations, interviews, and participatory engagements, we found that three variables became key determinants in how he approached the training process. Firstly, Antoni was not adequately prepared to meet the implicit expectations of airport administrators. For example, during one of our ride-alongs, Antoni walked us through varied aspects of his daily routine including a checklist provided to him by airport administrators to guide maintenance procedures of the floor cleaning robots. As Antoni went through the document, he grew increasingly agitated and circled five out of the fourteen tasks to indicate that he did not receive training on the selected items. “I don’t know what these things are,” he stated as he held the checklist, underscoring his confusion on administrative expectations that were meant to guide his day-to-day work.

Secondly, the process of allocating additional tasks and training to janitorial staff is done through a hierarchical process rather than one based on merit. For instance, janitorial staff members are presented with the same opportunities to grow professionally, including aspects of management that might be absorbed into their role or training on a particular service or product. Upon announcement, any interested parties may write their names on a sign-up sheet from which shift managers select who is given the opportunity, with priority given to the most senior staffer. Antoni emphasized that the option of opening up the opportunity to maintain the robots to additional staffers does not guarantee that managerial efforts are strengthened. Instead, according to him, the most senior staff member taking on additional responsibility does not mean that they are the most qualified or well-positioned to take on the task. Antoni saw a discrepancy between the skills required for the position and those possessed by workers most likely to be given the role, increasing the chances for the technology to be improperly managed. Thirdly, Northfield Robotics’ inconsistent communication on repair and maintenance updates, as detailed in the previous section, placed the safety of the general public and janitorial staff at risk. Antoni also noted being unsure of when remote software updates were made or when an issue flagged by cleaning staff had been addressed. “I just wish they would communicate,” Antoni repeatedly said throughout our ride-along, emphasizing the need for comprehensive follow-ups on requests, in addition to specific dates and times when updates would be made and if these changes would alter the robots’ mapped routes.

When we asked a technician from Northfield Robotics on ways to optimally troubleshoot the robot malfunctions, he framed it as a need to understand “how it is meant to be,” or how the robots were intended to perform — underscoring that “some customers . . . don’t

necessarily embrace the operators’ autonomy.” He stated that the biggest challenge is “getting people accustomed to the equipment in its operation” pointing to an expectation that all actors at the Airport—administrators, facilities, cleaning staff, and passengers—adjust to the design of the robot.

### 5.3 Concerns for Safety and Liability

**5.3.1 Janitorial perspectives.** An ongoing theme across our participatory engagements, observations, and interviews was the pressing concern with the safety of passengers. BFM and the County Authority that oversee the Airport see slip-and-falls—traveler accidents that can lead to legal ramifications—as a primary concern. Preventing and rectifying situations that may lead to such accidents was a core principle in janitorial staff’s work and efficiency directives they received. The malfunctions of the AI-powered technology heightened concerns for safety and liability amongst janitorial staff leading to catastrophic thinking grounded in near accidents they witnessed in their day-to-day work.

Four janitorial staff members who joined one of our participatory workshops immediately began to discuss how the shortcomings of the AI-powered robots could lead to safety hazards. All four of them had spent roughly five to ten years at the Airport as part of the cleaning staff and felt as though the choice to embed the technology to their line of work caused disruption. Jack expressed concern about the demand to be in, what seemed like, multiple locations with very little notice, due to the need to keep track of their typical route and the robots’ needs. His colleague, Aggie, underscored that the expectation to drop what they are currently doing to tend to the robots in a different location was unrealistic.

The conversation quickly led to a tallying of the near misses janitorial staff had witnessed on the job. For example, one staff member shared the story of a robot almost running into a passenger who suddenly stopped in their tracks to check their phone. As they were doing so, a robot headed in their direction only to miss the passenger by a slim margin. Others remarked that random passengers would jump in front of the robots to test with them, deepening anxiety about liability issues amongst janitorial staff. Aggie stated that they could see the robots falling down the escalator at some point. “It’s like the movie *Short Circuit!*,” Jack added. Laughter erupted and several more agreed that a partially functioning technology like the floor cleaning robots could depart from its intended path to wreak havoc on the wider public. *Short Circuit* is a film set primarily in a robotics lab for military technology where iteration and demos are common. Number 5, one of the experimental military robots, fears reprogramming and evades capture by venturing beyond the walls of the lab and into the public. The film follows his encounters with the general public and the disruptions Number 5 causes to daily life. The shared sentiment that brings together the film and the UV floor scrubbing robots at the Airport exposes the shared misgivings staff see between the film’s plot and the unfolding of the Airport’s deployment process for the floor scrubbing robots. All four agreed that there should be a role dedicated to robot maintenance and in communication to avoid janitorial staff bearing the cognitive load and emotional burden of caring for the robots in what seemed like constant anticipation of an acute risk to the public.



**5.3.2 Administrative viewpoints.** In an interview with an Airport administrator, he expressed that the “ultimate goal is to have a better tomorrow” by means of innovation. In the wake of the pandemic, this entailed responding swiftly to the acute public health crisis as an organization. Initially, the administrators were unsure of how to address an unprecedented moment. An operations engineer, for example, purchased an untested disinfection device marketed for cleaning handrails after seeing a write-up in the industry press. He recalled thinking, “Hey, why don’t we use this in [the US]? Because it was mostly in Europe [at the time].” Unfortunately, it ended up not being an appropriate fit for the context nor was it effective, but this example shows how airport administrators made formal and informal attempts to quickly respond to the uncertainty of the crisis in the name of safety for their staff and the general public. Staying in line with their broad “smart” airport vision, the Airport later partnered with Northfield Robotics who designated a technician to guide the robot roll-out process.

Working directly with the cleaning staff and serving as the primary point of contact to address mechanical and operational issues, the Northfield Robotics’ technician was the first to respond in the event of a robot malfunction. The technician typically received a notification directly from the robot’s system while also getting some type of electronic communication from cleaning staff. He then assessed whether to address the issue remotely or in person as he also understood that “it [wasn’t] good for the robot to be, especially in the high traffic area like the Airport, sitting like a dead duck.” According to Antoni and Rafael, they rarely overlapped with the technician due to the designated days for the technician’s site visits coinciding with Antoni’s days off. Antoni put into place a “makeshift practice” to determine for himself whether the Northfield Robotics technician came by to respond to maintenance issues. His method entailed parking the malfunctioning floor cleaning robot in a corner of the storage closet designated for the technology. On top of the robot, Antoni would place an unused scrubber over the area that required the Northfield Robotics’ technician’s attention. If the scrubber was moved in any way, then it signaled to Antoni that “someone addressed his concern.”

In addition to this “tactic” to gauge whether the technician’s help was received, Antoni pointed out two key areas during one of our ride-alongs where a robot had deviated away from its typical route and followed an unanticipated path: a set of rubber mats near the start of its route and the entrance to a retail shop typically at its halfway point. We first drove toward a medium sized seating area and a line of quiet shops. He pointed to the edges of the rubber mats in front of a freestanding cart and stated the robots “tore up” the corners repeatedly. Antoni then drove us a few inches from the entrance to a retail shop to illustrate how close one of the robots came to entering a store. The sales associate attested to the sudden, unexpected experience where she believed that the robot was about to enter the store as a customer was being served. “At the end of the day, it’s all about safety,” Antoni stated throughout our conversation.

During another observation, Tegan—one of the shift managers—pointed out two locations where the robots had or had nearly crashed into existing businesses. In the first location, Tegan stated, the robot ran into a concession stand. In the second location, it moved in the direction of restaurant seating missing their bar

stools by a slim margin. In all four instances, pointed out by Antoni and Tegan, they believed these run-ins immediately followed a remote software update administered by Northfield Robotics. Antoni wished there “was a clearer or better communication line” between Northfield Robotics and the cleaning staff, not to “know what the specific software updates are,” but rather “what the anticipated route and behavior changes might be.” However, the impact of such updates and the decision to update software in the first place was not conveyed to staff. The lack of communication from Northfield Robotics, as well as the lack of training efforts beyond the managerial team, made staff feel uneasy and arrive at the conclusion that the gap in communication posed a risk to several parties—retail associates, passengers, and janitorial staff themselves.

## 5.4 Automated Technology Indicative of Impending Future

**5.4.1 Janitorial perspectives.** Throughout our participatory engagements, acute concerns surrounding job security were voiced by the majority of the participants. Geoff, a janitorial staff member who was at first wary of speaking up, shared, “instead of bringing a machine, they should have hired two people.” He underscored the jarring nature of selecting machinery to conduct work rather than supporting the livelihoods of staff in the midst of a global pandemic. Margaret, a janitorial staff member who was upset about the additional time spent on cleaning after the robots, stated that the eventual demise of their vocation will be due to the implementation of AI-powered technologies. In response to Margaret’s frustration, Janice and Lucy—relatively new additions to the janitorial team—nodded in agreement as they, too, believed that the inclusion of automated technology meant that the end of their profession was inevitable. This stirred forms of doubt and speculation amongst the group as they asked “what is the purpose of these robots” and “does the UV light, the supreme technology, work?” The intangibility of evidence to support the claim that the transition was worth their time and fatigue bolstered individual and collective beliefs that hiring humans would be more beneficial. Geoff affirmed his initial statement before he left the room. He pointed to one of the folding chairs in the conference room and noted the black smudge smeared across the seat. As he highlighted the stain, he remarked “a human [would] see the stain on the chair and be able to address it immediately. I can’t say the same for the robot.” He underscored the adaptability of humans who can address issues at a moment’s notice, firmly making the point that the robot would never be able to provide the same results. The concern across most janitorial staff members we spoke with centered around who was being asked to shoulder the burden of pushing forward an *innovative* solution, particularly as it was being made during a time of acute precarity for them.

**5.4.2 Administrative viewpoints.** Our interviews with airport administrators and managerial staff revealed that they believed that janitorial staff did not subscribe to the myth that automation technology would evidently displace their work. Though one Airport administrator noted initial anxiety among staff may be “normal apprehension about new technology [generally],” he was confident it would quickly pass. Comparing the deployment to his previous professional experience in a union factory facing automation, he

felt as though the Airport’s approach to the technology roll-out adequately took this fear into account. Managerial staff underscored the attention placed on addressing the initial concerns janitorial staff had on the immediate impact of the robots to their job security as well as what it might be indicative of in the future. Rafael detailed that the janitorial staff “appreciated that he gave them answers,” and that he placed emphasis on the robots augmenting their existing work. Similarly, the technician from Northfield Robotics believed that “this kind of work helped [staff] be more successful” due to it “advanc[ing] their job skills, advanc[ing] their career skills to say that they are able to run a robotics curve.” Each key touchpoint for the janitorial staff—from airport administrators who make executive decisions to technicians who oversee the maintenance of the robot to managerial staff who shape their day-to-day operations—acknowledged staff’s initial fear of losing their jobs and believed these anxieties were addressed through careful communication.

## 6 DISCUSSION

From our two years of research—entailing qualitative interviews, observational research, participatory engagements—we actively sought to recuperate workers’ perspectives on and relationships to the enactment of technology deployment in the wake of the COVID-19 pandemic. Our primary line of inquiry on whose stories underpin these administrative and design decisions [32] remained the throughline that wove each phase of our research. By developing a robust and vivid illustration of their lived socio-material realities, we reveal a widening gap between administrators’ perception of staff [16] and workers’ increasing accumulation of tasks. The discrepancy manifested in a set of implicit expectations that informed organizational protocols and procedures that shaped the workers’ day-to-day, made evident through the direct accounts from janitorial staff at the Airport.

Through efforts to recuperate and re-center workers’ accounts in this research, we found that a reevaluation of and reorientation to method, as it stands, was equally vital to telling these stories anew as we delved into the gaps between administration and worker experiences. We build on traditions of counter-storytelling and counter-framing [30] to widen the perspectives from which design narratives are often told. This allowed us to gain insight from the perspectives of janitorial staff and their shift managers to provide a more thorough understanding on the evolution of work that has taken place since the height of the pandemic. Our workshops exposed the gravity of workers’ frustrations, the influence of administrator’s presumptions, and offered worker-centered alternatives to existing protocols and procedures. Our ride-alongs further revealed inconsistencies across scales and experiences from different positions within the Airport that compounded the day-to-day working conditions of janitorial staff. Above all, our direct engagement with janitorial staff underscored the undeniable importance of workers conducting invisible labor propping up technological systems and their advancement, without which the entire system would falter.

### 6.1 Grievances as Means to Shape Organizational Protocols and Procedures

The ability to air one’s grievances without fear of retribution is an essential part of any organizational structure, particularly within

unionized contexts such as the Airport. Through the recuperation of workers’ stories, we highlight the importance of holding a “feminist ear” [1], or staying open to hearing the complaints of those who bear the burden of deploying and maintaining the innovative technologies that often emerge from design and academic institutions [15]. We also point to the crucial role that the circulation of “war stories” [29] holds after typical development processes end. The exchange of knowledge surrounding recovery from unanticipated technological malfunctions connect individual grievances and incentive strategies in ways that could meaningfully reshape the initial design. From our workshops and interviews, we found that workers’ lived accounts attest to the consistent malfunctioning of the robots, while making legitimate diagnoses of potential core issues and suggestions for deepened development. Beyond designing with predetermined understandings of particular sites and the stakeholders who inhabit them, responsible innovation requires ongoing deliberation and imaginative processes centered on care and reciprocity [50, 51]. Toward this end, we recommend constructing spaces where complaints can be shared and building collaborations with organizations that have experience bargaining for workers’ rights to inform institutional, structural, and technological change.

Active collaboration with advocacy organizations places emphasis on recuperating stories of workers and the de-centering of designers and engineers in the full articulation of innovation. Through the vocalization of concerns and demands of the workplace, advocacy organizations converge individual claims and collective realities to inform and redirect institutional decision making. This pivotal role is exemplified in a recent case where, after a two month strike, hotel workers across the US with their union Unite Here negotiated a contract to include a clause that dramatically shifts power dynamics between administrators and frontline employees, specifically, in the age of AI-powered technologies [43]. This move marks an expansion of concerns from traditional “bread and butter” issues like pay and benefits to the need to negotiate tech implementation and accompanying training procedures. The details state that workers will be at the bargaining table to discuss the roll-out processes around new technologies, countering typical top-down approaches where managerial staff would determine deployment without consulting workers [43]. Advocating for a say in shaping equitable conditions and the (spatial, physical, and mental) day-to-day experiences of essential staff directly connects with the Airport’s janitorial staff’s desire for an active feedback loop between worker and Airport executives. This focus on reclaiming power around the implementation of technological systems in workplaces extends our site-specific research and brings it into a wider discourse. Not in isolation, these measures can be seen in relation to efforts to unionize essential industries with recent notable examples including Amazon in Staten Island, NY [44] and Starbucks stores across the US [45]. This growing interest in the labor movement calls on design researchers and practitioners to humbly approach implementation processes of technological systems and purposefully design conditions for worker-centered collaborations and partnerships to take place such that the future of essential work in the age of AI-powered technologies is designed with and for workers at the outset.

## 6.2 Workers as a Core Source of Ethical AI

Workers' perspectives underscored the inconsistencies in the deployment of technology while unveiling the institutional barriers to conducting ethical AI. From our participatory workshops, we found that janitorial staff were burdened with the malfunctioning of robots on a daily basis, amassing into an accumulation of unaccounted labor compounded by a lack of training. As a result, staff felt as if they were simply a means to an end. This insight contradicted the acknowledgement airport administrators offered during interviews on the importance of janitorial staff's role in a successful roll-out process. Through pairing participatory workshops with qualitative interviews, we were able to cross reference acknowledgments, intentions, and material outputs. The incorporation of participatory practices intentionally bridged a widening divide we witnessed in our fieldwork between managerial staff's understanding and the lived realities of janitorial staff. This misperception contributed to organizational protocols that deprioritized conditions that may relieve the accumulation of work for janitorial staff and reinforced asymmetrical power relations between administrator and worker. To subvert this process, our participatory practices—in line with their origins in the labor movement in Scandinavian countries—centered the day-to-day realities of janitorial staff's work, conceptually and methodologically, and framed deployment processes as politically situated and place-based.

These observations align with recent HCI scholarship on the intensified (but unacknowledged) work of adopting digital tools necessary for remote, flexible work arrangements. As many knowledge workers have experienced over the course of the COVID-19 pandemic, the pivot to online work has led to a need to learn digital maintenance skills to troubleshoot the tools regularly used, which workers report breaks up their workflow and takes time away from "real work" [52]. Whiting and Symon [52] note employees "complain about the technology but do not count up the hours spent and its equivalent in working time, accepting and internalizing the responsibility for such tasks as an inevitable consequence of 'choosing' to work flexibly." In other efforts, scholars seek to enumerate the hours of unpaid, invisible labor crowdworkers perform in order to find worthwhile tasks, message requesters, and manage payments via Amazon Mechanical Turk [53]. Newly accounting for this uncompensated work, they note a reduction in previously reported worker earnings by an average of nearly 25%. Taken together, this research calls out the need for continued interrogation of the effects of organizational pivots in technology use, as well as the ways in which low wage workers tend to bear undue burdens of innovation.

Turning back to our own field site, our qualitative interviews, half-day ride-alongs, and the application of participatory practices made it clear that the implementation process of AI-powered technologies was a vital part of determining the direction of a technological system. With this emphasis, we recommend repositioning workers as central figures to conducting ethical AI—for the purposes of having a roll-out process that is dignified and respectful, extending beyond efficiency objectives. This entails designing the conditions that allow for fair contract negotiations that center the worker; developing training tailored to the needs and capacities of

workers; determining the relationship between worker and technology based on their day-to-day realities; and setting administrative decisions on protocols in collaboration with essential workers.

## 6.3 Retelling and Remaking as Modalities for Narrative and Method Building

In line with the values of recuperation, we extend this approach to the development and configuration of methods with a critical eye on design's reliance on framing and frameworks—a methodological manner of demonstrating positionality and expressing normative understandings [30]. The idiosyncrasies of the janitorial staff's day-to-day and our continual practice of centering workers informed how we expanded "the reach of its investigative imagination to new formulations of research practice" [33]. In doing so, we actively deconstructed participatory design workshops, as they are typically practiced, to allow the socio-material realities of janitorial staff at the Airport to determine temporal, affective, and experiential forms of each session. This remaking considered the short window of time used to convene as a team prior to the start of their shift, their mental capacity to engage in a conversation at an early hour, design prompts to guide the brief engagements, and their preferred location at the Airport.

Actively reenvisioning workplace practices as they are traditionally rehearsed provided us an opportunity to move past a superficial acknowledgement of workers' experiences to one where this understanding is deeply embedded in the design of methods we used. In this light, we recommend evaluating traditional design research methods to ensure that they are indeed worker-centered. This entails allowing the socio-material realities of the workers to guide the development of the methods with regards to location, activity, materials, length, focus, and underpinning logics. We share these lessons as a way to offer ways to conduct worker-centered design as an application and in the construction of best practices for organizations that intersect technologies and essential work. In line with our findings on reorientation and reconfiguration to methods and application as they stand, we offer these insights with the understanding and acknowledgement of their complexity and contingency. Furthermore, our aim is to reposition workers in the discourse of ethical AI so that the design of their work is informed by the gravity of their contributions, in addition to the dignified manner for which it should be accounted.

## 7 CONCLUSION

Through the reconfiguration of how and whose stories are told within complex organizations, our research brings to the fore the pivotal role essential staff play in implementing technological systems and argues that their work *is* innovative, rather than supplementary. This paper draws from theories of invisible labor, everyday design, and the feminist strategy of recuperation to orient inquiry toward the lived realities of janitorial staff, foregrounding the need for a worker-centered framework in our collective, critical practice. As design researchers, it is important to continually reflect on the hidden aspects of our technological systems by returning to the question that foregrounds an understanding that sociotechnical processes are politically situated: *whose stories underpin our administrative and design decisions?*

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