Phenomenology and the Cognitive Sciences
https://doi.org/10.1007/s11097-024-09987-6

4E cognition, moral imagination, and engineering ethics education: shaping affordances for diverse embodied perspectives

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Accepted: 18 April 2024

Abstract
While 4E approaches to cognition are increasingly introduced in educational contexts, little has been said about how 4E commitments can inform pedagogy aimed at fostering *ethical competencies*. Here, we evaluate a 4E-inspired ethics exercise that we developed at a technical university to enliven the *moral imagination* of engineering students. Our students participated in an interactive tinkering workshop, during which they materially redesigned a healthcare artifact. The aim of the workshop was twofold. Firstly, we wanted students to experience how material choices at the levels of design and functionality can enable morally significant reimaginings of the affordances commonly associated with existing artifacts. We term this type of reimagining *world-directed moral imagination*. Secondly, through the design process, we wanted students to robustly place themselves in the lived embodied perspectives of (potential) users of their selected artifacts. We term this *person-directed moral imagination*. While student testimonies about the exercise indicate that both their world-directed and person-directed moral imagination were enlivened, we note that the fostering of robust person-directed moral imagination proved challenging. Using 4E insights, we diagnose this challenge and ask how it might be overcome. To this end, we engage extensively with a recent 4E-informed critique of person-directed moral imagination, raised by Clavel Vázquez and Clavel-Vázquez (2023). They argue that person-directed moral imagination is profoundly limited, if not fundamentally misguided, particularly when exercised in contexts marked by emphatic embodied situated difference between the imaginer and the imagined. Building upon insights from both the 4E field and testimonies from critical disability studies, we argue that, while their critique is valuable, it ultimately goes too far. We conclude that a 4E approach can take on board recent 4E warnings regarding the limits of person-directed moral imagination while contributing positively to the development of moral imagination in engineering ethics education.

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Published online: 27 May 2024

Keywords Moral Imagination · Experiential imagination · 4E cognition · Engineering Ethics Education · Embodied education · Disability · Ableism

1 Introduction

One's views about the nature of education and the processes conducive to learning are intimately tied to ideas about the mind and cognition. How we theorize processes of acquiring, retaining, and applying information; how we theorize the ways in which people make sense of the world and develop new modes of understanding; and how we theorize where those processes are located, all shape how we think about what we do and what we aim for as educators. Western educational contexts have been influenced by a broadly Cartesian conception of the thinking mind. According to this tradition, learning is an emphatically individualistic and disembodied process (Bertucio, 2017). In recent decades, new developments in the cognitive sciences have challenged this Cartesian view. Often grouped under the term *4E* cognition, these developments suggest that acquiring, deepening, and refining one's understanding of the world, which is to say *learning*, constitutively involves aspects of a learner's **E**mbodiment (their morphology, affects, and sensorimotor skills) and their **E**mbeddedness in a meaningful landscape of "affordances," where affordances refer to the perceivable possibilities for action available within the environment of a living cognitive being in virtue of their morphology, their embodied skills, their concerns and affects, and, in the human case, the sociocultural and material practices that they have been habituated into (Gibson, 1979; Rietveld & Kiverstein, 2014). On this 4E view, learning **E**xtends into the environment, where both artifacts and other people can play an enabling role in what and how we learn. Finally, on a 4E view, a learner's cognitive relationship to their sociocultural and material context is dynamically **E**nacted. Enaction connotes the idea that cognizing the world is not a matter of agent-neutral representation but of dynamic existential adaptive sense-making: as embodied world-embedded beings, we maintain a viable perspective onto the world through meaningful exchanges with a world that ineluctably matters to us.

4E approaches to cognition are increasingly introduced in educational theory and praxis, fueling new pedagogical strategies centered around embodiment, interaction, and hands-on material engagement (See Hutto & Abrahamson, 2022; Macrine & Fugate, 2022). Lawrence Shapiro characterizes this development in normative terms, arguing that:

> "old school' instruction, in which students sit at their desks observing teachers at blackboards or memorizing formulas or studying graphs, should be replaced with a method of instruction that recognizes and capitalizes on the contributions that bodies and environments make to cognition. (2022, xix)

The pedagogical value of 4E for subject matters such as mathematics (Goldin-Meadow et al., 1999, 2001; Macrine & Fugate, 2022), language learning and reading comprehension (Glenberg et al., 2004), and physics and astronomy (Gallagher & Lidgren, 2015) has already received significant attention. By contrast, ethics educa-

tion has lagged behind this scientifically informed move towards more embodied and interactive approaches in educational design. As researchers who are compelled by 4E insights and who teach and research *engineering ethics education* [EEE], we see this as a noteworthy knowledge gap.[1] In an effort to bring 4E insights explicitly into EEE pedagogy, we developed, implemented, and assessed an EEE exercise that took the form of a hands-on interactive tinkering workshop. In what follows here, we home in on what the exercise revealed about one specific ethical competency, namely *moral imagination*.[2]

There is a widely shared belief among EEE scholars that moral imagination is a valuable ability for engineers to develop (Cf. Callahan's 1980, Harris et al., 1996, Coeckelbergh, 2006; Zhu, 2020). That said, and as is often the case with philosophical concepts, there is no universally agreed-upon definition of moral imagination within the EEE literature; nor is there a broad agreement on how moral imagination is to be operationalized pedagogically. As such, we will begin our discussion with a brief overview of some of the ways in which moral imagination is defined in the EEE literature (Sect. 2). On this basis, we propose a distinction between two forms of moral imagination, namely *world-directed* and *person-directed* moral imagination. World-directed moral imagination, briefly put, refers to the ability to attend to the world as it *could* be by creatively reframing or reimagining the world with an eye to moral values. We define person-directed moral imagination as a virtual engagement with the experiential point of view of another person that reflects a responsiveness to them as a sense-making being who occupies a rich lived perspective onto the world.[3] While these forms of moral imagination can come apart both conceptually and practically, we argue that it is their combination that is of emphatic significance for the moral training of engineering students.

Against this theoretical backdrop, we discuss (in Sect. 3) how our 4E-informed material tinkering exercise sought to enliven students' moral imagination. The exercise was inspired by the artwork of disability rights activist Sue Austin, as presented in her TEdEx talk "Deep Sea Diving … in a Wheelchair" (2012). Austin, who has a mobile disability and gets around in a wheelchair, creates work that materially changes her wheelchair in ways that celebrate human embodied diversity, inviting people to reimagine the negative meanings typically associated with her (life with her) wheelchair. Our exercise involved a similar activity of material tinkering, with students working in small groups to creatively alter a selected healthcare artifact used in contexts of disability, (chronic) illness, and rehabilitation. Our aim was for stu-

[1] To be sure, many engineering ethics educators 'on the ground' already acknowledge the embodied and interactive dimensions of learning and are exploring pedagogical strategies broadly aligned with 4E views on learning (Cf. Tormey et al., 2022). Yet Cartesian assumptions remain stubbornly intertwined with 4E-aligned intuitions about higher education, muddling our sense of what we aim for in our teaching and how to optimally encourage learning through the pedagogy we design and the learning spaces we build and enact.

[2] We describe the exercise set-up and the data collection in more detail in Van Grunsven et.al. 2024a, which discusses how the exercise can contribute to inclusive STEM education by accommodating neurodivergent learning styles.

[3] This is in line with a view of moral imagination articulated in the works of Iris Murdoch. For an account of the link between Murdoch's ethics and 4E cognition see Van Grunsven 2022a,

dents to experience and reflectively engage with how material changes to these artifacts, made with tinkering materials, can open up new and ethically pertinent ways of looking at the affordances of those artifacts (thus enlivening world-directed moral imagination). To inform the process, students were asked to engage with the lived experiences of people who use those artifacts in their daily lives (appealing to their person-directed moral imagination). To assess the success of our exercise, we bring in our own observations as educators as well as testimonials from students who participated in the exercise.[4] What emerges on this basis is a complicated picture of the potential and limits of operationalizing moral imagination. While students describe an enlivening of both their world-directed and their person-directed imagination, we noticed problems with respect to the fostering of genuinely robust person-directed moral imagination.

In response to this failure, we ask whether this can be mitigated in future iterations of the exercise and whether and how 4E insights might be of help here (Sects. 4 & 5). To tackle these questions, Sect. 4 delves into an extensive engagement with a recent proposal from Clavel Vázquez and Clavel-Vázquez (2023). They argue, *on the basis of 4E insights*, that person-directed moral imagination, or "experiential imagination" as they call it, is profoundly limited if not impossible as a result of the robust way in which our imagination about the lives of others is shaped by our own unique embodied affective perspective and our individual history of interactions with the environment. As a result, they are pessimistic about the epistemic value of experiential imagination. If they are right, these epistemic shortcomings have moral implications: what we define as person-directed moral imagination, namely a virtual engagement with the experiential point of view of another person in a manner that reflects a responsiveness to them as a sense-making being who occupies a rich lived perspective onto the world, amounts to something like an oxymoron on Clavel Vázquez & Clavel-Vázquez's view. This, in turn, would entail that (engineering) ethics educators might have to forego attempts to foster person-directed moral imagination, going against the widely held view in EEE that person-directed moral imagination is an important and feasible EEE competency to foster. However, while Clavel Vázquez & Clavel-Vázquez's critique carries valuable lessons for the operationalization of person-directed moral imagination in EEE, we argue that their critique ultimately goes too far and overlooks relevant insights that open up a different perspective. What many testimonies from disabled people show and what a 4E perspective on cognition can help capture theoretically is that we must consider the ways in which the shared built technological environment can play a role in whether we succeed or fail to imagine the embodied lives of differently situated others as sense-making beings who occupy their own rich lived perspective onto the world. EEE should work to explicate this powerful link between the robustness and accuracy with which we imagine our way into other people's lives and the technologically engineered world of affordances that we inhabit together. EEE Pedagogy that targets the explication of this link can encourage engineering students to reflectively and imaginatively con-

[4] The data sets collected and analyzed can be found here: https://doi.org/10.4121/20020154.v1 and https://doi.org/10.4121/20115983.v1.

tribute to the material shaping of environments in which a more diverse array of embodied perspectives is seen, interacted with, (re)imagined, and designed for.

1.1 World-directed & person-directed moral imagination in engineering ethics education

One of our primary goals as engineering ethics educators is to get engineering students to recognize that engineering is not a value-neutral activity but that it is a way of 'doing ethics.' Engineered technological artifacts can embed ethical values (e.g., autonomy, privacy, solidarity, inclusivity) as well as pernicious biases and value-systems (such as ableism, racism, and sexism). Examples of this abound. The speed bump, for instance, affords human action in a manner that materially embeds the value of safety into the shared environment (Van de Hoven, 2013). Augmentative and Alternative communication technologies afford people who are unable to use their natural speaking voice with autonomy-enhancing forms of self-expression (Van Grunsven & Roeser, 2022). More perniciously, hostile architecture materializes classist dehumanizing prejudices, excluding houseless people from public spaces (Rosenberger, 2020). Similarly, traffic lights that only offer visual crossing signals embody an ableist bias against blind pedestrians (Dokumaci, 2023).

If the built technological environment co-constitutes the space of human affordances, and if this space is capable of promoting ethical values as well as harboring problematic ideologies and biases, then it becomes ethically vital that engineers in training learn to identify and reimagine the relationship between the technologies they develop, the affordances that those technologies introduce into the world, and the bearing that this has on differently embodied situated people. However, when it comes to finding educational methods up to this task, much work remains for EEE as a discipline. To explore a novel approach at our own university, we thus looked to 4E and its emerging pedagogical methods for inspiration and insight, designing an exercise that aimed to enliven and deepen the *moral imagination* of our engineering students. In order to evaluate to what degree our exercise achieved this goal, we must begin by answering a seemingly simple question: What exactly do we mean by moral imagination? We answer this question here, turning to the specifics of our pedagogical exercise in the next section.

As is often the case with philosophical concepts, there is no universally agreed-upon definition of moral imagination in the EEE literature. Several EEE approaches to moral imagination build upon Marc Johnson's influential account, which holds that moral imagination entails "the ability of a … situated self to reflect critically on its own construction of a world, and to imagine other possible worlds…." (Johnson, 2014, , p. 241). In a somewhat different vein, Coeckelbergh (2006) proposes that "the enhancement of moral imagination can help engineers to discern the moral relevance of design problems, to create new design options, and to envisage the possible outcomes of their designs." Kirkman (2017, 2017a) heralds moral imagination as a capacity engineers need for making sense of the ethical aspects of the complex problems they'll face in their work, particularly around conceptualizing problems as ethical, opening themselves up to alternative framings and points of view of oth-

ers.[5] Hess et al., 2017 argue that the educational value of moral imagination lies in how "it enables engineers to consider the needs and values of numerous stakeholders with whom they may never directly interact, but who will be affected by the use and impact, including the unintended use and consequences, of their solutions" (p. 535). Finally, we mention Frey (2015), who argues, in one of the most developed accounts of moral imagination in EEE, that teaching moral imagination in EEE consists of three components:

> Through [1] multiple framing, engineers achieve transperspectivity and break through prejudicial mindsets to address other cultures from suitable points of view. In order to adapt to minds differently situated, engineers [2] role-take with others by projecting into their shoes and collecting their feel of a situation. Through [3] dramatic rehearsals, engineers can test the implementation of decisions and designs in rich and emotionally textured worlds that are constructs of imagination (236).

What can we extrapolate from this sketch of proposals? We propose a differentiation between two types of abilities alluded to in these various accounts. The first type of ability is *world-directed*. Moral imagination, on this view, enables a creative reimagining of the world with an eye to moral values. That is, moral imagination enables a person to attend to the world as it *could* be; as a place that can harbor different meanings, possibilities for action, and consequences, affecting how, for instance, justice is distributed, how moral communities are carved out, and how living beings flourish. The second type of ability attributed to moral imagination, as visible in Kirkman's, Frey's and Hess's proposals, is *person-directed* and concerns virtual responsiveness to the perspective of another person, to feel for their situation, appreciate their concerns and rich lived experiences.

We propose that both forms of moral imagination are of emphatic relevance for the ethical training of engineers.[6] In its *world-directed form*, moral imagination is of emphatic relevance because engineers, when they innovate, are in the business of reimagining and materially shaping the world, introducing new tools and sociotechnical systems that engender new practices and affordances. Although engineers (in training) do not standardly conceive of their activities through this normative lens, they are (at least implicitly) working with a world-directed, morally imaginative sense of how their innovations will introduce new possibilities, new ways of living, and new ways of responding to societal issues. They might imagine, for instance, that ambient assisted living technologies create new ways of aging safely in one's own home; that brain-computer-interfaces create novel forms of communication that can benefit people with severe paralysis; that social robots might help combat loneliness; that solar radiation modification can mitigate the devastating consequences of global warming

[5] Jalali et al. (2021) argue that moral imagination should include the body, and especially embodied experiences of suffering and pain.

[6] This is true especially when innovations are intended to be radical rather than incremental.

for planetary flourishing, etc.[7] One of our goals as engineering ethics educators is for students to gain an awareness of how processes and products of innovation embody and materialize a certain world-directed moral imagination. If and when these materializations are proliferated into society, they gain legislative powers, with engineers (and the companies they work for) effectively imposing the materialized expressions of their moral imagination upon the lives of others (Winner, 1990).

This shows the importance of world-directed moral imagination to go hand in hand with person-directed moral imagination. As our earlier examples of hostile architecture and traffic lights showed, the artifacts produced through innovation are known to shape environments that are more conducive to the agency and well-being of some situated embodied beings than to others. Hence, the world-directed acts of materialized moral imagination that engineers engage in urgently demand moral imagination in its person-directed form, with engineers reimagining the world not just from their own perspective but also from the perspectives of differently situated embodied beings. Indeed, many engineering ethics educators aim to instill an awareness in their engineering students to attend meaningfully to the needs, desires, and concerns of differently situated stakeholders. It remains an open question, though, how to operationalize this? How can we design EEE exercises capable of enlivening our students' moral imagination in the twofold sense just described? We now turn to this question via a discussion of our 4E-informed tinkering exercise. First, we discuss the ideas underlying the exercise, which involves looking at Austin's activist artwork from a 4E perspective. Then, we discuss how we put the exercise into practice and how students responded to the exercise.

1.2 An embodied, material, and interactive (Moral) reimagining of artifacts and differently situated Bodily lives

A 4E perspective sees imagination as entangled with materiality and informed by our perceptual experiences that are, in turn, shaped by embodied skills and worldly interactions (Cf. Johnson 1993; Malafouris, 2014; Van Dijk & Rietveld, 2020; Gallagher & Lindgren, 2015; Rucińska & Gallagher, 2021; Kimmel & Groth, 2023). Working from these commitments, our tinkering exercise aimed to enliven both our engineering students' world-directed and person-directed moral imagination through an embodied, interactive, materially engaged route. Our guiding idea was that a creative hands-on engagement with artifacts could encourage engineering students to grapple with existing values and biases embedded in (medical) artifacts, to open up imaginative new affordances for the artifact, and to engage with the lived embodied experiences of (potential) users of those artifacts.

As discussed in the introduction, the exercise was inspired by the work of artist and disability rights activist Sue Austin. The motivating drive behind Austin's work is an existential desire to overcome a dehumanizing experiential mismatch between her own embodied lived experience of her life with the wheelchair and the ways in which others imagine her life to be. After "an extended illness changed the way"

[7] Instead, it is fairly common for engineers (in training) to understand engineering activities and the technologies resulting from those activities as value-neutral and apolitical (Cf. Cech, 2013).

Austin "could access the world," she successfully incorporated a wheelchair into her body-schema. The chair allowed her to vastly expand her sensorimotor field of affordances, and experience exciting new forms of sensorimotor sense-making (she mentions "whizzing" around with exhilaration, the wind blowing in her face). The chair, in her words, had given her "an enormous freedom" (2012). At the same time, she recounts the sense of others primarily perceiving her chair – and her life with the chair - in terms of loss and limitation, a perspective that, to her detriment, she had started to internalize and that made her feel invisible in social space.

This experience is by no means unique to Austin. Perceptions of disabled people's lives that foreground lack, deficiency, and limitation are all too common. In engineering contexts, this outlook has translated into a widespread interventionist approach to disability tech, with engineers developing technologies aimed at curing, restoring, or mitigating a presumed lack of or deficiency in ability (Williams et al., 2023). Many scholars working in the fields of critical disability studies and crip technoscience have criticized this stance, which STS and critical disability studies scholar Ashley Shew refers to as *technoableism* (2020). As Shew points out, technoableism is typically not the result of engineers working with pernicious ableist intentions. Rather, the problem is one of *imagination*. Specifically, when non-disabled engineers imagine their way into the lives of (potential) disabled users, they frequently do so by framing the experience of disability and what makes being disabled challenging by attending to deficiencies in abilities (a person lacking the ability to hear, walk, perceive things visually, use their natural speaking voice, etc.) and imagining, from their non-disabled point of view, what it must be like not to have access to those abilities. The late bioethicist and wheelchair user Bill Peace exposes the flatness and shallowness of such imaginations with effective snark:

"Your typical bipedal person … is led to believe all paralyzed people share one goal in life–walking. Please cue the soaring inspirational music accompanied by the brave and noble young man or woman struggling to walk surrounded by health care professionals, computer scientists, and engineers who share the same ritualized ideal" (2015).

Technoableists, in other words, engage in forms of person-directed imagination that are very often reductive and at odds with the rich lived experiential lives of disabled people (see not only Austin and Shew, but also Baggs, 2007; Sinclair, 2012; Dokumaci, 2023). That is, they engage in person-directed imagination that falls short of being person-directed *moral* imagination; they do not attend virtually with the experiential point of view of another person in a manner that reflects a responsiveness to them as a sense-making being who occupies a rich lived perspective onto the world.

As Hanne de Jaegher (2013) has argued in the context of autism, such a reductive take on disabled bodily life is fundamentally misguided from an enactive 4E perspective on the living body as always, in the first instance, the cite of adaptive sense-making. In her words:

the enactive approach to cognition … brings a dimension of personal significance right to the core of cognition. Sense-making is based in the inherent needs and goals that come with being a bodily, self-organizing, self-maintaining, precarious being with a singular perspective on the world. Sense-making plays out and happens

through the embodiment and situatedness of the cognitive agent: her ways of moving and perceiving, her affect and emotions, and the context in which she finds herself, all determine the significance she gives to the world, and this significance in turn influences how she moves, perceives, emotes, and is situated (2013, 1).

As De Jaegher (and other enactive 4E researchers with her) furthermore argues, individual human sense-making is intimately bound up with the sense-making of others; it is often 'participatory', where how we are perceived by others – the possibilities for action we are taken to afford them – informs whether and how we are engaged with in ways that can enact shared spaces of meaningful interaction. This insight helps to capture Austin's sense of urgency to close the gap between her own lived experience and the inaccurate way in which others are seeing and imagining her. When one is inaccurately perceived primarily in terms of lack, loss, and limitation, when one's body as a city of rich sense-making is overlooked or ignored, this detrimentally affects how one is interacted with in social space, contributing to what Arseli Dokumaci refers to as a "shrinkage of affordances" (2023). Austin's strategy for changing people's perception of her runs via the artifact that so emphatically shapes how people imagine their way into her life. She materially reimagines her wheelchair as a deep sea diving device and shares video images of herself diving with her chair to get people to look at the world in a new way, with the wheelchair shedding its meaning as a marker of lack, deficiency, and otherness and obtaining the meaning of a "powerchair," an object of desire that affords possibilities for free exploration. This, in turn, is meant to enrich people's person-directed imagination, away from imaginations centered around loss and lack, towards imaginations of her bodily life as a divergent but no less valuable site of rich sense-making.

Austin's work aligns in many ways with 4E insights about the relationship between art and imagination. In his inaugural address, *The Affordances of Art for Making Technologies* (2019), Erik Rietveld lauds art's potential to open us "up to unconventional affordances, including provocative possibilities for changing what we … take for granted, for breaking habits" (32). Austin's art accomplishes this by instantiating what Malafouris calls "thinging:" the making of "new things that scaffold the ecology of our minds, shape the boundaries of our thinking and form new ways to engage and make sense of the world" (2014). Austin's work thus speaks to the ways in which "the imagination is 'entangled with matter and the affordances of things.' … such that in a material imagination the actual and the possible can be coexperienced." (Kimmel & Groth, 2023, p. 12). Indeed, it matters that we, as spectators of Austin's work, can see the chair both in terms of 'the actual,' i.e., in terms of the common meanings it is typically associated with, and in terms of the possible reimagined affordances it also enables. It is this coexperiencing of the actual and the possible that enables us to see a familiar object in a new light. Gallagher & Lindgren (2015) might characterize Austin's work as facilitating a "metaphoric transformation," which "involves acting-as-if or seeing something as something else" (396). According to Gallagher & Lindgren, such metaphoric transformation can serve as a powerful vehicle for learning, "allow[ing] learners to transfer understanding of a familiar domain to a new,

unfamiliar domain" (398).[8] Rietveld identifies the important role that material metaphoric transformations can play in the education and practices of engineers, enabling them to "the discovery of radical possibilities and meanings that [they] had never considered, and sometimes to new ways of living with the technology" (2019, 17).

Our "tinkering exercise," which sought to encourage such *material enactive metaphoric transformation*, had students work in small groups of 4–6 students to alter existing technological artifacts used in contexts of disability, rehabilitation, and illness. Artifacts up for redesign included a walker, a hearing aid, a stoma bag, and a phone designed for people with dementia (see Fig. 1).

Students were also provided with a variety of tinkering materials (such as cardboard, rubber bands, foam, plastic parts, paper, clips, scotch tape, bottle caps, etc.). Prior to the exercise, the students watched Austin's TedEx talk and attended a lecture that shed light on the complicated role of technology and design in the lives of disabled people via readings from the field of critical disability studies. Additionally, students had been instructed to familiarize themselves with the lived experiences of potential users through the reading of testimonials and, where possible, through real-life engagement (one student, whose group reimagined the affordances of a hearing aid, had a deaf family member whom she had consulted prior to the workshop. Another student, whose group materially reimagined a telephone designed for people with dementia, consulted her mother throughout various stages of the tinkering workshop about her experiences as a care worker for people with dementia). We then gave students the instruction to apply the insights they had gained through theory and testi-

Fig. 1 The artefacts that were available for redesign

[8] While the 4E accounts discussed in this section are not focused specifically on *moral* imagination, the link with Austin's works helps to see the ethically charged implications of material reimaginings of affordances.

mony to the material redesign of a medical artifact. Around 200 students in total participated in the tinkering exercise in tutorials that looked more like workshops than ethics classes (see Fig. 2). The classrooms felt and looked engaged, all the students were active, exploring and discussing different tinkering materials and manipulating the artifact (one group took a walker that they were working on outside to feel what it was like to push it uphill in windy or rainy weather conditions). The workshops ended with the students showcasing their altered artifacts, explaining how and why they had made their specific material changes.

Three students who participated in the workshop were retroactively interviewed, with each student indicating that the exercise enlivened what we here term their world-directed and person-directed imagination. Participant 1, for instance, captures the way in which their world-directed imagination gained depth and specificity through material embodied engagement:

> *"what makes the workshop special in that kind of way is actually moving it around, and using it. … Feeling something and using makes it more confronting. So, you have a more specific way of looking at a certain artifact instead of just imagining it." [1.62].*

In terms of enlivening their person-directed imagination, Participant 1 notes:

> *"We all were imagining how that would turn out. Like how would that person go up the hill with the tricycle and what did that person need to have a more comfortable way of using it, for using the artifact. So we eventually just, we were all thinking about that and discussing what kind of scenario would that person be in, what if it was my grandma, how would she react? [1.10].*

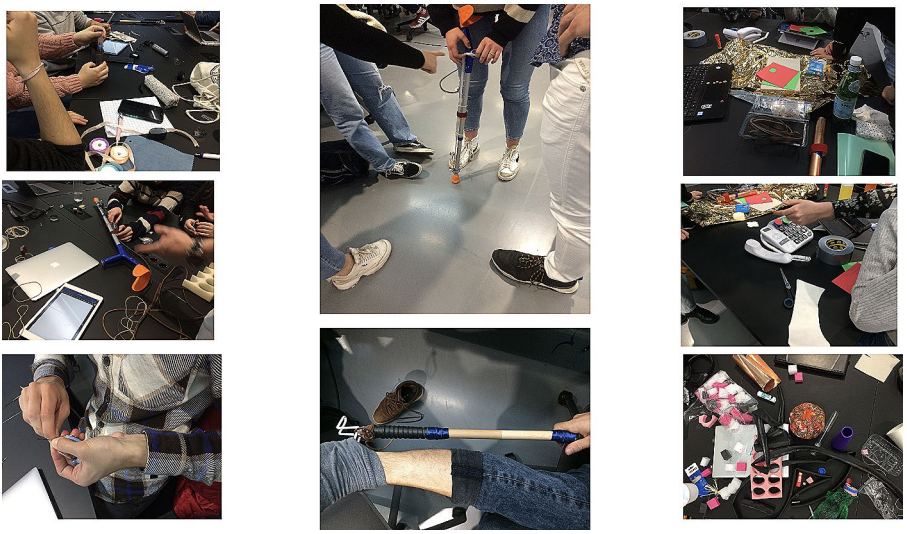

Fig. 2 Impressions of the tinkering workshop

Relatedly, they add:

> *"if you're on your own for instance and you don't have the workshop, you don't have these scenarios you can think of, you don't have the way that we work together, then you stay in your own bubble and you just think that you can just do whatever is good in your view, but you don't necessarily take into account other people's view and other people's experiences." [1.12].*

Participant 2 gives expression to a gained awareness of how artefacts can be much more than assistive 'tools,' in the sense that they can become deeply entangled with people's experiential lives:

> *It also helps my imagination as well, to see how can we change things to make them better in a way that's the best and does not intervene with the person … … we don't want to just see how a tool can help people, but we want to also see how the tools can be embedded inside the life of people … I didn't actually think about that before the project. I was just thinking that tools like this just to help us, but its more than that. It's there to be a part of our lives. [2.62]*

Similar to Participant 2, Participant 3 connects their creative tinkering with the material object (world-directed imagination) with person-directed moral imagination:

> *"the object there makes it really concrete what the object would be capable of or not. And you can put yourself more into the shoes of someone who would use the object" [3.62]. […]"If you don't have an experience using these things then you also do not have the sensitivity to what actually are the necessities of the people using it." [3.100].*

As these quotes indicate, students seemed to feel their imagination come to life as they materially reconceived the affordances of given artifacts, while becoming reflectively aware of how artifacts as loci of affordances impact the lives of end-users. Students also reported becoming more aware of the need to open up to the perspectives of differently situated end-users. This, it seems to us, is what many proponents of moral imagination in EEE precisely hope to achieve. However, while our students recall becoming more attuned to the different perspectives of their imagined end-users, we also noticed a tendency among many students to remain satisfied with armchair efforts at person-directed moral imagination. Recall that we had explicitly required students to seek out testimonials from the end-users prior to attending the workshop. Yet a striking number of students ignored this instruction. Though there were noteworthy exceptions, many students took their own ability to imagine the experience of the other from the armchair as a suitable substitute for engaging other perspectives through first-person testimony. Not surprisingly, this was also reflected in some of the redesigns. For instance, one group that was redesigning an artifact for an imagined aging person equipped it with an overwhelming array of technological gadgets, even though this emphatically goes against many testimonies from the current generation of aging adults (see also IJsselsteijn et al., 2020). This underscores

the importance, in the EEE context, for world-directed moral imagination to go hand in hand with person-directed moral imagination.

The problem with armchair imaginings of the lives of others is powerfully captured by Shew (2020), who warns that "perspective taking" in "thought experiments" and "simulations" can be "an actual taking, a ripping away of experience, a stereotyping and collapse of experience, a willful ignorance of the real people whose lives are being subsumed and used" (2020:611). Situating this concern into an educational context, Shew remarks:

> When I teach my class on Technology & Disability, which has readings mostly from the disability community, some students are surprised by the narratives they encounter, for many of them come in expecting to learn about new technologies that are "fixing" the lives of disabled people. This is the aim of many technological developments designed "for" disabled people by nondisabled people. But these designs take disabled people as imaginaries to be designed on, instead of people. (2020, 613)

What can we do to encourage our students to engage with their (potential) end-users not as imaginaries marked by "a stereotyping and collapse of experience," but as sense-makers who occupy a rich lived perspective onto the world? And what role, if any, can person-directed moral imagination play in this? In the next section, we turn to recent literature in 4E cognition to home in on this question.

1.3 A (critical) 4E look at the limitations and potential of person-directed moral imagination

A 4E view of embodiment and (social) cognition can help us understand the temptation, seen in many of our students, to engage in person-directed imagination from the armchair. As 4E research has highlighted, we often perceive the embodied expressive intentional lives of other people as perceptually accessible without much effort (Gallagher, 2008). We see a person's happiness directly in their expressive smile or hear their sadness directly in their sobbing (Scheler, 2008). This ability is grounded in a primordial interconnectedness between our own lived perspective and the embodied lives of others. To speak with Merleau-Ponty:

"the communication … of gestures comes about through the reciprocity of my intentions and the gestures of others, of my gestures and the intentions discernible in the conduct of other people. It is as if the other person's intentions inhabited my body and mine his" (Merleau-Ponty 1962, p. 215).

This doesn't mean that our understanding of others is automatic or inoculated from error. In fact, as Fuchs and De Jaegher emphasize: "intersubjectivity is regarded as a circular process in which the cogniser constantly influences the other by his actions and vice versa … cognising and acting are interdependent, and there is no pregiven other." (2009, 469). Much in the same way, there is no pre-given self. As Vasu Reddy puts it: "the self is an intangible and constantly moving point of flux; in the process of constant moving and engaging with the world and other people, it is constantly being re-shaped as an entity in relation and is gradually building up awareness of

itself in these relations" (2008, 148-9). Nevertheless, these processes are enabled by and grounded in an intercorporeal starting point of interlocking perspectives between expressive embodied minds who typically know how to make sense of and with each other. Now, because other people's experiential perspectives typically do not constitute a problem for us in our day-to-day dealings with them, one can see how we can be tempted into thinking that armchair efforts of engaging in person-directed imagination will suffice. Over the course of our lives, we have built up a rich grasp of the meanings expressed in the bodies of the people with whom we interact. This experientially acquired knowledge of other embodied minds instills a basic confidence in us that we can often imagine from the armchair what others might be experiencing from their perspectives.

That said, while the embodied minds of others are, in a sense, open to view, a 4E perspective on (social) cognition simultaneously entails that there is a duality to the body's epistemological role in our ability to understand the minded lives of others and imagine how things might be from their perspective. A person's experiential perspective onto the world, their sense of what is salient in any particular context, is shaped by the *specific* embodied abilities they have acquired, their specific morphology, their unique history of body-environment interactions, the specific sociocultural practices they are habituated into, and the specific needs that they have as precarious bodily beings. Clavel Vázquez and Clavel Vázquez (2023) have recently argued that this "robust embodiment" imposes serious epistemic limits on what we can learn about *other* people through armchair acts of person-directed "experiential imagination," to use their term (2023).[9] Building upon 4E and critical phenomenology (which is partly informed by critical disability studies), they argue that "imaginers lack the relevant history of sensorimotor and affective interactions that would allow them to interact with the imagined scenarios in the relevant ways as to accurately summon the relevant aspects of the perspective" (2023, 1413). The challenge is twofold: Firstly, person-directed experiential imagination involves an attempt to recreate another person's lived perspective onto the world, where this perspective and its specific phenomenological saliences are the product of that person's unique affective, embodied, sociohistorical situatedness and their unique history of worldly interactions. In their words: "to fully understand what is at play" for the person whose perspective we are experientially imagining "we need to consider the whole agent involved in the exercise in her sociohistorical relations" (2023, 1410). Secondly, attempts at recreating this perspective are undertaken by an imaginer who is constrained by their own specific affective, embodied, sociohistorical situatedness and unique history of worldly interactions. Clavel Vázquez & Clavel-Vázquez conclude that:

"unfortunately, the robustly embodied constraints hinder the epistemological value of experiential imaginative projects that involve *a significant departure* from one's history of sensorimotor and affective interactions, *as is the case for those differently situated*. … The value of experiential imagination is more limited than acknowledged

[9] As Rucińska and Gallagher (2021) have argued, this robust role of our embodied situatedness enables it to precisely play an epistemically valuable constraining role when we imagine what things might be like for us in a variety of different (future) scenarios. The sedimentation of our embodied interactions and gradually acquired abilities and practices will enable us to meaningfully imagine how things will play out for us in different imagined contexts. a.

in the cases where it is invoked as being needed the most: understanding others. Moreover, *the more radical the departure from imaginers' situation*, the more limited the epistemological value of experiential imagination will be" (2023, 1414, our italics).

Thus, they conclude that a 4E view of embodiment "substantiate[s] pessimism about the epistemological value of experiential imaginative projects aimed at recreating the perspective of others differently situated," as "it can hardly be divorced from who we are and where we have been." According to Clavel Vázquez & Clavel-Vázquez, the robust embodied nature of experiential imagination thus prohibits accurate imaginings of the other's rich lived perspective, which we have presented as vital for person-directed *moral* imagination. Instead, they urge that "understanding others," particularly "those differently situated," "demands that we go beyond our own imagination," for instance, by attending to "their testimony of what it is like" to inhabit their embodied perspective (2023). In fact, they propose that, in our efforts to understand the perspectives of the "differently situated," we might be better off to altogether replacing experiential imagination with insights gathered through testimony:

"if [testimonial] stipulations are what completed [an imaginer's] picture of [the other's] perspective, we might question *why he needed* experiential imagination in the first place. All he needed was [the other's] testimony. Moreover, why think that experiential imagination, rather than the … [testimony], was epistemologically valuable?" (2023, 1415).

Now, to a degree, Clavel Vázquez & Clavel-Vázquez' critical pessimism aligns with the issue that motivated our tinkering exercise, namely Austin's felt mismatch between her own rich lived embodied perspective and people's reductive imaginings of it. To a degree, their view also aligns with Shew's warnings about the collapsing of experience that can occur in acts of armchair perspective-taking. However, while we endorse the critical spirit of Clavel Vázquez & Clavel-Vázquez' pessimism, we also believe that their skepticism goes too far. In fact, as we will argue now, it goes against the grain of insights both central to 4E and to testimonies of the sort given by Austin, i.e. testimonies from disabled people that reflects a desire for others to imagine their lives in a way that more accurately reflects their rich lived embodied perspective.

To unpack our concerns, let's take a closer look at the passages just cited, beginning with the passage that suggests listening to testimony can replace efforts at experiential imagination. There are two things we want to note about Clavel Vázquez & Clavel-Vázquez' point. Firstly, they seem to over-intellectualize the act of engaging in experiential imagination when they imply it is an activity about which we can decide that we might not "need" it and can instead replace it with another activity instead: reliance on testimony. This characterization of experiential imagination as a deliberately chosen act that we can simply forego stands in tension with a 4E perspective on the phenomenology of our intersubjective lives from early infancy onward, permeated and shaped by the embodied perspectives of others. Whether we want to or not, person-directed experiential imagination is something we (or most of us) cannot opt out of. Of course, this fact of our psychological make-up doesn't entail that experiential imagination enables us to "consider the whole agent … in her sociohistorical relations," nor does it guarantee that our experiential imaginings, grounded

in our intercorporeal interactions with one another, are accurate (Clavel Vázquez & Clavel-Vázquez, 2023, 1410). But the idea that experiential imagination *should* be able to give us a full picture of the other's lived situated perspective is not necessary for it to have epistemic value, nor is it supported by a 4E-phenomenological view of what it means to accurately make sense of other people. It is fully in line with a 4E take on the hermeneutic process of gaining gradual awareness of ourselves and others through interaction to see experiential imagination as an activity that is both vital and incomplete; enabling and guiding the hermeneutic process of understanding another person while also requiring continuous enrichment and revisions through those interactions.

This gets us to our second objection. Clavel Vázquez & Clavel-Vázquez present us with an either/or choice between flawed experiential imagination and testimony, but it isn't obvious why experiential imagination and testimony should not work together. It seems difficult to make sense of the epistemic value of testimony without involving experiential imagination. The testimonial expressions of another become meaningful for us insofar as we take them up and connect them to the larger story of their experiential life, which seems to require ongoing attempts to imagine, from their perspective, what their testimony means to them. The problem, we suggest, is not experiential imagination as such, but the epistemically hubris assumption that our imaginings are by themselves sufficient and complete.[10] We propose that a hermeneutic process of imagining the other in a manner that is truthful to the particularly and richness of their sense-making life requires a combination of interpersonal interaction, testimony, and experiential imagination, where we must take the accuracy of our experiential imaginings as revisable, providing us with temporary clues capable of informing further engagement (e.g., by enabling us to imagine what might be a valuable follow-up question to a giver of testimony).[11]

While always revisable, some experiential imaginings get things emphatically wrong from the get-go. To imagine our way into Austin's life with her wheelchair by imagining it as centered around lack, loss, and deficiency is plainly inaccurate as it utterly fails to match her own lived experiences. Thus, there seem to be more or less accurate ways to bring people in view, with imaginings that flatten the other's experiential lives, reducing them to tropes, stereotypes, and assumptions of deficiency on one end of the spectrum, and imaginings in which we aim to be responsive to the other as a person with a rich experiential life on the other end. One problematic upshot of the Clavel Vázquez & Clavel-Vázquez view is that by framing experiential imagination as profoundly if not completely skewed by our own embodied perspec-

[10] We borrow the term "epistemic hubris" from Eva Kittay, who uses this term while criticizing Peter Singer for refusing to enter into genuine interaction with Kittay's cognitively disabled daughter on the basis of the assumption that he knows enough about her life to evaluate its worth.

[11] At some point Clavel Vázquez & Clavel-Vázquez seem to double down on their pessimism when they propose that even "engagement with narrative artworks" insofar as these engagements themselves depend "on experiential imagination" is constrained by the imaginer's embodied perspective, "shap[ing] how one engages with them" (1414, 2023). Hence, Clavel Vázquez & Clavel-Vázquez's position seems to make it difficult even to take seriously Shew's insistence that the "hearing [of] stories, fiction and non-fiction, from others' perspectives" is "fundamental to … hav[ing] imagination about how the world could be, and could be different" and, through that, to "consider who belongs in those futures." (2023 Chap. 6).

tive, we can't seem to make a difference between the inaccurate imaginings that Austin aims to dislodge and imaginings in which Austin might feel more adequately recognized. Austin and many other disability rights activists with her, are asking for a different way to imagine their embodied experiential lives (for a case in point, see also Mel Baggs', 2007 video "In My Language"). They are not saying: stop trying to put yourself in my perspective because accurate imaginings are impossible. They are saying: the things you are imagining about our bodily lives are misguided and uninformed and you can do better. While Clavel Vázquez & Clavel-Vázquez clearly want to honor different embodied perspectives, we worry that their whole-sale skeptical dismissal of experiential imagination in the context of "differently situated" people makes these calls for improved experiential imagination nearly non-sensical.

On Clavel Vázquez & Clavel-Vázquez's account, there is a sense in which our embodiment, appears to be trapping us in our individual perspectives, closing us off from genuine contact with the other. This is a strikingly Cartesian solipsistic place to end up when starting from 4E commitments. But upon closer examination, it appears that this solipsistic streak applies primarily to imaginings directed at others who are "differently situated," where "the more radical the departure from imaginers' situation, the more limited the epistemological value of experiential imagination will be" (2023, 1414). Note that, in making this distinction, Clavel Vázquez & Clavel-Vázquez make room for the epistemological value of experiential imagination in instances where we place ourselves in the perspective of another whose situatedness more closely resembles that of our own. But if that is the case, if person-directed experiential imagination is not *in principle* epistemically vacuous but if it depends on certain differences, then it matters a great deal how we understand the sources of those differences and how we determine what counts as too much difference. Now, although they don't offer specifics about when difference become too radical to support epistemically valuable experiential imagination, it seems clear that, on Clavel Vázquez & Clavel-Vázquez's view, our individual bodies with their distinct histories of interaction are where the source of difference is located. By contrast, we highlight that 4E offers more than a story about individual embodiment: it also offers a story about the role of shared contexts of significance, of the social but also technologically built environment that delineates what affordances are available and dominantly normative, shaping what we attend to together, how we make sense of and with each other (Cf. Krueger & Maiese, 2018; Van Grunsven 2022a, Van Grunsven & IJsselsteijn 2022a; Dokumaci, 2023). If we take this seriously, then 'the differently' in 'the differently situated' can stem in part from the artefacts and systems with which we live *and which we can change*. Indeed, this was precisely Austin's message: that changes in the landscape of affordances can change how we perceive and imagine the lives of those who might seem very differently situated. There are countless other examples from critical disability studies that drive home this point. One such example is that of neurodivergent HCI designers who are pleading for communication technology that is capable of being responsive to neurodivergent communication dyads. Such communication technology does not just enforce neurotypical communication norms onto autistic communicators but also enables neurotypical communicators to acquire an understanding of autistic expressivity and communication norms:

"The design space of assistive technologies for autism, as with other communication barriers, can and should include technologies that involve both interlocutors in the communication process. This moves beyond a medical model focused on "fixing" a person and recognizes that any communication should include adjustments by everyone. For example, in addition to an augmentative communication device that helps autistic children to approach their peers in "socially appropriate" ways, it could be helpful to create tools that help NT children to approach their autistic peers in "autistically appropriate" ways" (Mankoff et al., 2010).

Communication technologies grounded in the ambition to "fix" autistic persons helps to enact communication spaces that fail to do justice to autistic sense-making and deepens the "radical" difference (and distance) between neurotypical and autistic communicators, whereas communication technologies that reflect a view of interpersonal communication as requiring "adjustments by everyone" contribute to a levelling of the communicative playing field – facilitating interactions and testimonial exchanges that might support a better mutual understanding between people whose embodied situatedness might seem insurmountably divergent.

To be fair, Clavel Vázquez & Clavel-Vázquez leave room for the possibility that imagination can be seen as a skill that can be enriched through actual embodied interactions with the world, leaving room for the kind of view we have just advocated for. In their words: "the embodied approach opens the door to the idea that experiential imagination is a skill and, in consequence, that our imaginative capacities can be improved … The caveat is, of course, that performance cannot be improved through imagined interactions alone. A skilful imaginer would need to expand her repertoire of actual interactions to broaden the scope of possible engagements that will present themselves as available in imagination" (23, 1414). They add, however, that such a view requires a specification of accuracy conditions. "Scaffolding leaves open the possibility that experiential imagination might be a useful tool with the relevant training. But optimists would need to determine what would count as a successful experiential imaginative exercise" (23, 1414). Our proposal here has been that successful experiential imaginations avoid a flattening of the other's experiential life and instead reflect a responsiveness to the other as a sense-making being with a rich experiential perspective. We expand upon what this can mean in the context of fostering person-directed moral imagination in the EEE context in the next (and final) section.

1.4 4E take-aways for EEE

We just proposed that the built technological environment can play a significant role in the way in which we perceive and interact with people and, accordingly, in the depth and scope of our experiential imaginings of the lives of others. If this is right, then we can encourage and facilitate access to other people's perspectives by designing for interaction, by leveling the material technological playing field of interaction, by facilitating spaces of shared sense-making. This makes it all the more important for those who are learning to give shape to our shared technological environment to critically engage their moral imagination, to recognize and learn from its limits while utilizing its potential to build environments in which a more diverse array of embodied perspectives are seen, interacted with, (re)imagined, and designed for.

Bearing this in mind, we developed a 4E-informed EEE exercise that, among other things, required students to actively seek out testimonials from end-users who were situated differently. Yet, as discussed, many students ignored this instruction, seemingly working with the assumption that experiential imagination by itself would generate epistemically and morally relevant information about what it is like to be the end-user for whom they were redesigning their artifacts. Thus, while we reject Clavel Vázquez & Clavel-Vázquez' pessimistic conclusions, we align ourselves with the critical spirit of their argument, which points to a warning note for educators who attribute automatic moral significance to perspective-taking. We cannot be satisfied as EEE teachers when our exercises, aimed at enlivening students' moral imagination, accept experiential imagination as a sufficient route for engaging with (and designing for) end users who are (to different degrees) situated rather differently from (most of) our students.[12] Instead, we propose that an awareness of the limits of experiential imagination ought to be considered an important ethical learning goal, especially for engineers-in-training who are tasked with designing technological artifacts and systems for a variety of stakeholders. One way to pursue this could be by asking students to engage in armchair experiential imagination and to have them contrast the assumptions generated through this activity with insights that they go on to acquire through first-person testimonies and interactions. This would set up an experiential way of getting engineering students to confront the limits of experiential imagination and embrace the need for interaction and serious testimony-driven stakeholder engagement. Understood as a learning opportunity, experiential imagination's morally relevant epistemic value would then depend not so much on its ability to provide accurate contentful knowledge about what it is like to be an other, rather, its ethical-epistemic value would primarily lie in the epistemic humility that can be instilled in students when reflecting precisely on how their particular embodied situatedness limits experiential imagination (for a similar point, see Van Grunsven et al. 2024b) 4E literature on social cognition, which captures the duality of our embodied understanding of the experiential lives of others, could be brought in to help students understand both the tendency to rely upon experiential imagination and the ethical and epistemological limits of doing so.

That said, while we take on board the warnings about the limits of experiential imagination argued for by Clavel Vázquez & Clavel-Vázquez, we also believe that there is more to experiential imagination and the epistemic role it can play in the education of engineers than acknowledged by Clavel Vázquez & Clavel-Vázquez. While armchair efforts of engaging in person-directed moral imagination are by no means morally laudable by themselves; while they can sustain all sorts of false and morally pernicious assumptions that flatten the experiential embodied lives of others, it seems too quick to cast aside the shifts and changes in perspectives described by our students as epistemically (and morally) vacuous. Should we attribute no ethical-epistemic significance to a student who recounts a shift in their own sensibility, away

[12] Motivated by a similar concern, Mark Coekelberg nuances his view on the potential of moral imagination when he suggests that it is constrained by inevitable "condition[s] of opacity, [whereby] our knowledge of the relevant worlds and narratives is always in principle incomplete" (Coeckelbergh, 2010, p. 191). One of these conditions, he maintains, stems from "the psychological problem of our limited capacity to feel and imagine (a "hardware" problem, to use an ICT metaphor)" (Coeckelbergh, 2010, p. 191).

from assumptions that health care artifact simply intervene into a person's life for the better towards seeing those artifacts as needing to be meaningfully interwoven with a person's "whole life"? Should we not attribute ethical and epistemic significance to students capturing a breaking out of "your own bubble" towards a "taking into account other people's views and other people's experiences?" For people who will become professionals tasked with engineering artefacts for stakeholders with whom they will likely never interact, such shifts seem like worthwhile moments to build upon in attempts to foster moral imagination. However, if experiential imagination were as epistemically vacuous as Clavel Vázquez & Clavel-Vázquez suggest, it becomes difficult, if not impossible, to make sense of these shifts as ethically and epistemically meaningful.

Overstating the limits of experiential imagination can be particularly problematic in engineering contexts that have a history of ignoring or discrediting the lived perspectives of (marginalized) stakeholders (Shew, 2023). Responding to that history, we, as engineering ethics educators, are precisely trying to get engineers in training to take seriously the perspectives of different stakeholders. Thus, we propose, the limits of experiential imagination need to be made explicit and utilized as an important ethical learning moment, without giving up on the ambition to strive towards more accurate imaginations of what the experiential lives of other people might be like. While absolute accuracy conditions for person-directed moral imagination cannot be spelled in advance, we can learn important take-away lessons from testimonies like the one shared by Austin: more or less accurate person-directed moral imagination resists a flattening of experience and reflects and supports an ongoing process of responsiveness to the other as a sense-making being. We now recognize that this was, in fact, also missing from our exercise in its first instantiation. While testimonials were required to be sought out in advance, the tinkering process itself was unconstrained by checks from differently situated direct stakeholders. In future iterations, the perspective of differently situated embodied stakeholders will have to be incorporated throughout the exercise to provide continual constraint and interactive enrichment of our students' moral imagination. While engineers contribute to the development of artifacts and systems that will be used by a variety of stakeholders, practices of engaging with different stakeholders and testimonies throughout the R&D process may enable them to discover reliable patterns for exercising the skill of person-directed moral imagination. As we have discussed, of primary concern in engineering contexts (particularly in contexts of healthcare tech) is the technoableist tendency of non-disabled engineers to imagine from the armchair how the lives of disabled people might warrant cure or improvement. Such experience-flattening armchair imaginings are prone to loop back into the world-directed imagination of engineers, informing the design of artifacts that not only fail to match with the needs and lived experiences of end-users but also threaten to further sustain and materialize ableist habits in how non-disabled people imagine their way into the lives of disabled users. Thus, we conclude that in this context, person-directed imaginings by engineers that are not anchored in a standpoint of presumed lack, imaginings that do not flatten but that virtually engage with the other as a sense-making being, deserve to be seen not only as epistemically more accurate but also as an example of moral imagination.

Author contributions All four authors were involved in the initial conception of the research. Janna van Grunsven, Lavinia Marin and Trijsje Franssen conducted the qualitative research discussed in Sect. 3 of the paper. The writing was done by Janna van Grunsven, Lavinia Marin and Andrea Gammon. Janna van Grunsven was responsible for writing the paper as a whole. She wrote significant portions of Sects. 1, 2, and 3, and was the sole author of Sects. 4 and 5. She also streamlined and edited the final version of the paper to ensure the paper's narrative and voice were unified and was responsible for the revisions of the paper. Lavinia Marin wrote portions of Sects. 1 and 3. Andrea Gammon was responsible for writing parts of Sect. 2. All three authors contributed to the paper in its entirety in the form of commenting and editing.

Funding This research was funded by the 4TU Centre for Engineering Education [grant number TBM_ERE_2021_02_4TU.CEE.TUD] & the NWO Dutch Research Council, which funded the projects: Mattering Minds: Understanding the Ethical Lives of Technologically Embedded Beings with 4E Cognition [grant number VI.Veni.211F.055] & the Gravitation research programme Ethics of Socially Disruptive Technologies [grant number 024.004.031].

Declarations

Ethical approval The research conducted on our?tinkering exercise? was approved by the Human Research Ethics Committee of Delft University of Technology.

Informed consent All participants in the research signed an informed consent form.

Competing interests N/A.

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