Turning Back to Planet Earth: Defining the Aesthetics of a New Sustainable High-Tech

Ylva Fernaeus
Umeå Institute of Design
Umeå University
Umeå, Sweden
EECS
KTH Royal Institute of Technology
Stockholm, Sweden
ylva.fernaeus@umu.se

Abstract

This paper explores the aesthetic value shifts required for sustainable design of so called 'high-tech' products, highlighting an increasing down-to-earth ethos within the field. Using a spaceship metaphor and drawing from principles of post-industrial design and visions for long-term sustainable transformation, a high-level analysis is presented of how grassroot activist cultures and alternative tastemaking practices are currently steering designs towards the systemic, earthy and organic. This direction is illustrated by diverse examples from within the TEI discourse that investigates new material approaches and that critically challenge conventional aesthetic orientations. While such approaches can be criticized for insufficiently addressing interactive and electronic components, this research underscores their essential role in reimagining technology and materials, to navigate complex cultural interdependencies and advance sustainable design futures.

CCS Concepts

• **Human-centered computing**; • **Interaction design**; • **Interaction design theory, concepts and paradigms**;

Keywords

Sustainable TEI, post-industrial design, Aesthetics in interaction design

ACM Reference Format:

Ylva Fernaeus. 2025. Turning Back to Planet Earth: Defining the Aesthetics of a New Sustainable High-Tech. In *Nineteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '25), March 04–07, 2025, Bordeaux / Talence, France.* ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3689050.3704935

1 Introduction

This essay is in response to the conference theme of *'Sustainable TEI'*, for the 19th annual conference dedicated to Tangible, Embedded, and Embodied Interaction. Much research has concerned interaction design for sustainability [see e.g. 2, 3], with the theme of Human-Computer Interaction for Sustainability now a flourishing research area of its own, and we see how social, ethical and environmental concerns have been increasingly recognized also within more technology-oriented fields like TEI. Here, we discuss some of the *aesthetic orientations* and approaches to sustainability in works presented within this academic discourse and discuss its broader implications for design as well as for theory. The term aesthetics is here used as is common in interaction design, with attention to concepts such as user experience [see e.g, 10, 32, 39, 50], at interplay with varied and shifting cultural norms. While aesthetics is sometimes implied as an insignificant surface layer of interactive products, it is fundamentally shaped by as well as shaping cultural contexts, with powerful ethical implications [38]. It is thus an embedded quality of our world and the futures we hope for, and therefore affects the shapes and materials of the designs we produce, as well as the lifestyles and practices we want our design efforts to fit into.

TEI is fundamentally concerned with 'high-tech', by studying, developing, and showcasing designs at the cutting edge of interactive technology. Here we use the *Spaceship* as a metaphor for the design discourse in this research area. Stemming from the space age era of the 1960s, it is no coincidence that high-tech design has often spoken to us using a sci-fi inspired visual language. Also, conceptually for the topic of sustainability, the spaceship doubles as a longstanding metaphor for understanding systemic and environmental dependencies, as in Buckminster Fuller's concept of the 'Spaceship Earth', established within that era [10]].

As any research domain of design or engineering, the field of TEI idealizes the new, and in a sense therefore also the short-lived, and many have argued that this general culture of short-termism is one of the main causes of the current instability of the world [see e.g. 27, 41]. As famously phrased by Arturo Escobar [19], we need *"a significant reorientation of design from the functionalist, rationalistic, and industrial traditions from which it emerged, and within which it still functions at ease, towards a type of rationality and set of practices attuned to the relational"* (p42). Considerations for sustainability have a long tradition in the design discourse [50], even within the early modern movement [20], yet it cannot be neglected how the very principle of mass production, which still governs much of industrial design, has had significant impact on our research field and the contemporary world as we know it.

TEI '25, March 04–07, 2025, Bordeaux / Talence, France

ACM ISBN 979-8-4007-1197-8/25/03
https://doi.org/10.1145/3689050.3704935

Figure 1: Examples of cool, 'beigeless' computing. A) The Metadesk, by Ullmer & Ishii, 1997 ©ACM. B) G-Speak, by Undekoffler et al, set in the film Minority Report, by Steven Spielberg 2002 ©20th Century Fox. C) Lumino by ©Baudisch et al, 2010. D) inFORCE by ©Nakagaki et al, 2019.

The notion of Post-Industrial Design was introduced around 1980, as design theorist Nigel Cross [13] argued that the 'hyperexpansionist' Modern Movement approach to design had to be phased out. This new approach would entail a resource-conserving attitude to materials and production, it would advance quality and promote *"social and economic life reorganised in small-scale units" [*13*, p. 6].* This could be said to represent a call for re-uniting the craft disciplines with design, and a revival of the so-called Arts and Crafts move-ment, which from within the crafts field since more than a century had represented an ongoing cultural resistance to the industrial de-sign project. The concept of crafting had become increasingly seen as a form of hobby, folk art, or as a playful school activity among children, and the post-industrial design ideals brought with it a re-appreciation of traditional crafts as *precious* [68]. Now, almost half a century later, this notion of post-industrial design appears more relevant than ever. The post-industrial design ideals, as articulated above and by many others since, can be seen reflected both on the contemporary arts scene [9, 60], in subculture [57], and even in the commercial sector. It has clear parallels to the so-called 'maker movement' [18], calls for local-, environmental- and socially just production [58], and the large amount of low-tech crafts pop-ularly shared and showcased via online platforms such as Etsy, Instructables, TikTok and Instagram. Attention to the handmade is also present in a variety of contemporary design styles, such as wabi-sabi [72], steampunk [66], neo retro [75], and bricolage [72]. At the yearly TEI conferences, we observe an ever-growing enthusiasm for projects related to manual crafts, such as bamboo weaving [24], stained glasswork [23], shoemaking [45], and crochet [26].

A shift away from modernist ideals in early HCI research (as reföected e.g. in its focus on single user interfaces and search for objectively optimal solutions) has in TEI previously been articulated as a reorientation of design values towards the pragmatic, material, social, and subjective [22]. A main consequence of this, as highlighted by Fernaeus et al in 2008 [22] was that designers need to acknowledge a world more complex than is often assumed, yet they did not bring attention to the environmental disruptions caused by technology, and neither did they reflect on the entanglements of other-than-human lifeforms as part of interactive contexts. A similar critique was formed in van Dijk et al's 'Radical Clashes' [14], highlighting the gap in orientation between research stemming from a human-centred design perspective, and research conducted from a perspective of engineering. Brenda Laurel [40] later pro-posed that design work should be grounded in an awareness that we belong to the biosphere, and in which 'Technology is not the other' and 'Nature is not the other'. Lenton and Latour [41] similarly high-lighted how, rather than focusing on relationships between specific organisms, the ambition should be to maintain a 'planetary-scale self-regulating system'.

Brought into design practice, these new principles could hold an enormous potential in the drive towards long-term sustainable transformations, a theme we currently see many research projects grappling with. Some well-known conceptual explorations include 'Eternally Yours' [49], 'Technology Heirlooms' [35], 'Gaian IxD' [40], 'Interaction Design Otherwise' [15, 25], and 'Wanting to live here' [5]. More concretely we see growing number of projects that explicitly engage with other-than-human entanglements, not only with plants and animals [2, 34, 36, 47, 74], but also luminescent algae [31], bacteria [56], yeast [8], mold [53], and even human body fluids [29], as parts of interactive systems. The use of organic and bio-based materials is seen both as surface materials and for interactive functions, but also as core contextual elements or as props for staging design to be set in warm and liveable environments. This essay follows directly upon these developments, by a more explicit focus on what these works might bring to our understanding of aesthetics in relation to long-term sustainable transformations.

2 Background

In Jeffrey Bardzells introduction to the practice of Interaction Criticism from 2011 [4], he used the then contemporary, now classic, tangible interaction design exemplar *Lumino* [7] as an example case for critique. In his analysis, Bardzell brought to light some obvious but rarely discussed aspects of interaction design from a perspective of visual aesthetics, including the inherent masculine coding of a cold blue colour scheme, and its sleek and geometric forms. The analysis revealed a deep aesthetic preference, prevalent also in much previous works in the field, coded with similar visual expressions. From the Metadesk [32], to G-Speak, famous from Steven Spielberg's 2002 science fiction film Minority Report [63], to InForce [46] and Radical Atoms [33] – they all display a preferred taste for translucent objects set in dark rooms, illuminated by technology (see Figure 1). Though this family of projects were originally

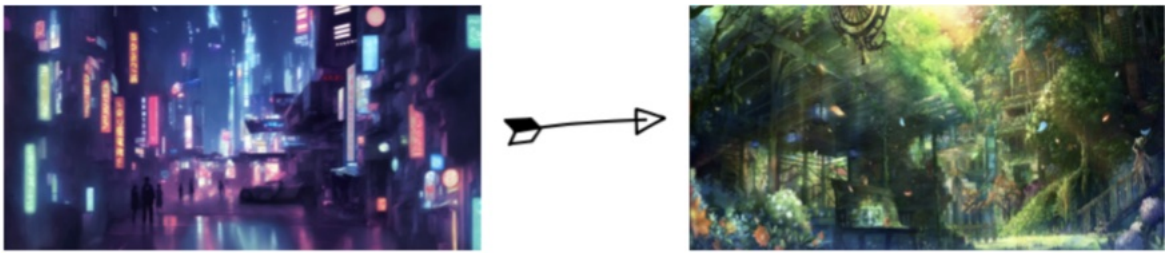

Figure 2: From Cyberpunk (left) to Solarpunk (right).

described as a reaction against the standard desktop paradigm of the time, as in Underkoffler's notion of *'Antisedantory Beigeless Computing'* [71], it can also be argued to reflect a self-image of technology as detached from natural ecosystems.

Here, we would like to point out how this shaping of a 'high-tech taste', which was so prevalent in many of the early TEI exemplars, holds some clear aesthetic parallels to the dystopian style of the 'Cyberpunk', and that the Minority Report did not depict a future anyone was hoping for. The aesthetics of the Cyberpunk, developed as a sci-fi inspired design style during the 1990s, tightly followed the legacy of early industrial ideals, with a machine aesthetics drawing directly on modernist visions of the future [62]. At a surface level one may see this reflected in much of early HCI work as a tendency to scientize certain forms, promoting e.g. geometrical shapes above ornamentation, and adverse attitude to colour (see e.g. [6]). The design ideals of the cyberpunk aesthetics were challenged already by Kathrine Hayles in 1999, proposing alternative visions of the posthuman, not to be *'seduced by fantasies of unlimited power'* [28].

In contrast, the science fiction genre of Solarpunk [55, 76] represents an aesthetic ideal that imagines an optimistic future in which our current problems have been successfully solved. Recurring technologies in these visions include solar panels, solar ovens, windmills, vertical gardens, bicycles, earthships, greenhouses, aquaponics, and technology being repaired, repurposed and reused. As a contemporary design style, Solarpunk has been most influential in architecture, where instead of lifeless glass and steel, the designers look forward to shared gardens, crafted woodwork, and cosy textile interiors (see illustrations in Figure 2). In interaction design we can see this aesthetic traced visually in surface appearances and layouts, and in the many niche projects concerned with nature, gardening and (inter)personal care, as already mentioned above.

In particular, we would like to point to a growing range of design exemplars that expose technology alongside and interwoven with green plants, organic materials, the outdoors, and rudimentary everyday use contexts populated by people. Importantly, this tendency appears not limited to technology but also other areas of design. Compare Breuer's iconic Bauhaus chair *'Wassily'* from 1925, with the contemporary *'Green Hideaway Chair'*, by European design agency Front in collaboration with the DIY chain Hornbach, from 2023 (see Figure 3). The two pieces represent fundamentally different ideals in terms of production, use, and visual appearance, but perhaps most prominently in its relationship to *the living*, where the hideaway chair doubles as a climbing structure for a live plant, growing from under its seat. Designed along with instructions for construction and assembly, it also elevates the value of the home built as a form of local production, and downplays, or overrides, the value of the factory-made.

One could see the above developments as a parallel to how notions around the posthuman have swept over HCI in different waves. The first wave in the late 1990s, in critiques of the sci-fi inspired discourse of the time, articulating cognition as distributed, embodied, and situated through thinkers like Katherine Hayles [28], Lucy Suchman [64], Lakoff and Johnson [39]. Many of the principles of tangible and embodied interaction stem from these ideas. In the late 2010s, we began to see a second wave of emphasizing more-than-human designs as an approach to sustainable futures of interactive systems, now drawing more extensively on feminist new materialist scholars such as Donna Haraway [27], Karen Barad [3], and Rosi Braidotti [10]. While the first wave worked to most part as a counter-reaction to the disembodied ideals of the early computer era, the contemporary discourse on posthuman HCI is coming from a broader philosophical discourse of new materialism, eco feminism, and postcolonial studies. Our current discourse of TEI provides an exciting blend of these different strands, one focusing more on designing for human practice, while the latter takes on a broader eco-social perspective, focusing more on relations and interferences. Both strands however share the fundamental grounding in human experience and survival as deeply situated in the material world. In the following, we will try to articulate how these ideas are reflected concretely in contemporary design directions.

3 Returning to "Eternally Yours"

Back in the late nineties, about the same time as the rise of the concept of tangible interfaces [32], Verbeek and Kockelkoren [49], listed four possible strategies for sustainable product design: 1) to focus on services, e.g. repairing and renting, instead of new products, 2) eco-design, i.e. minimise pollution throughout a product's life cycle, 3) recycling, of the whole product and its components, and 4) working to expand a product's life span. While their mission focused on the final point through a design vision called 'Eternally Yours', all four strategies are still relevant pointers to revisit in the context of sustainable tangible and embodied interaction design. How may these seemingly simple principles translate to the contemporary world of advanced high-tech products, and our felt experiences in the interaction with such artefacts? How might current theories around eco-social entanglements resonate with these design principles, and how might they interconnect with ongoing tastemaking practices and aesthetic ideals? Below follows an overview of how

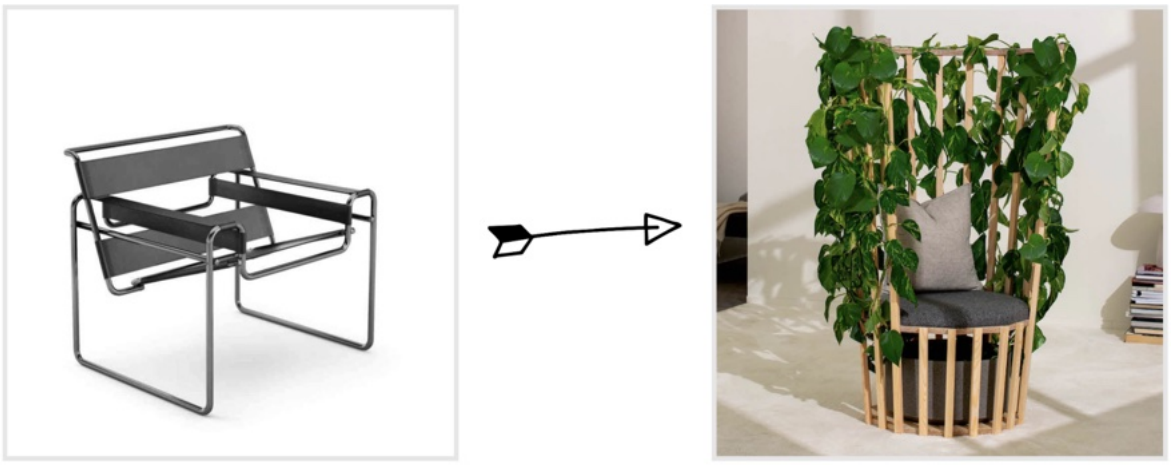

Figure 3: From Bauhaus to Hornbach. Left: 'Wassily' chair by Marcel Breuer, 1925-26. ©Knoll, 2024. Right: 'Green Hideaway Chair', by ©Hornbach in collaboration with Front Design, 2023.

contemporary works approach each of these strategies. Thereafter follows an analysis of how these approaches can be understood through a broader lens of aesthetics in contemporary culture.

3.1 Services

The first strategy highlighted by Verbeek and Kockelkoren was to focus design efforts on *services* such as repairing and renting, instead of mere production of new physical products. This resonates directly with current principles of the sharing economy, which blends interaction design, typically via smartphone apps and connected devices, with people, places and physical things. Development of such services are now tightly intertwined with physical product design. This means that beyond 'mere software', services to support shared use of the product is now often an inherent part of the physical design, with everyday examples such as smart speakers used in families and at social gatherings, electronic house locks, communal eBikes with mechanical functionality connected to online payment models, and a variety of ticketing solutions used for public transport. One may argue that today's electronic products are indeed as much about services as of production of goods.

There are still many wicked problems surrounding this setup, ranging from everyday media devices losing their functionality due to unforeseen changes in the media landscape, to horror stories of users of medical prostheses being ripped off their new body parts as MedTech startups lost their funding for continued maintenance [59]. The types of services that Verbeek and Kockelkoren talked about were aligned more specifically to the sharing economy in a pre-smartphone world, and the current reality highlights that new troubles have appeared. Perhaps most paradoxically, despite this abundance of services, people in our service-oriented and so-called post-industrial society still use up much more resources than any other civilization [40].

These examples highlight how, compared to the days of Eternally Yours, today's design efforts take place in *fluid assemblages* of connected devices and services [54], with for instance a connected loudspeaker requiring not only an internet connection but also a user account for some of its operations, and a subscription to a music library service for other operations, which in turn requires a smartphone with associated applications, connections and accounts. These are fundamental features of most current high-tech gadgets, and which every interaction designer in this domain will need to be adjusted towards.

Designing for shared use has indeed been a fundamental theme in much research at TEI, not least at works concerned with the design of physical interactions in real world settings, but attention to how these technologies align with online services has remained relatively limited. Yet the steady flow of initiatives for sharing- and circular use holds much potential in terms of sustainable use of advanced technology. The current theoretical emphasis on relations is exactly in line with this understanding, which will bring more weight to how the interplay between service designs in the real world may hinder or promote long-term sustainable use practices with and around high-tech products.

3.2 Eco-design

The strategy of *eco design* aims to minimise pollution from a product's entire life cycle through e.g. the use of organic materials, local production, and minimized waste during use, packaging and transportation. As repeatedly reiterated within the discourse of TEI, the design of computer systems can be claimed to fundamentally be about the shaping of electrical currents (bits) [70]. Yet, the default context for design within this field has until recently been based on conventional, industrial ways of living, with assumptions of, for instance, an endless and affordable supply of energy, for the shaping of bits, and for manufacturing of tangible elements [30].

One of the main concerns for TEI is *tangible* interaction, i.e. interactive systems that are partially based on graspable items, such as cards, blocks, dolls, pens, and other physical objects, which forms a design space that historically has covered some of the most innovative, but also some very mundane forms of interactions. One of the most common, yet undistinguished, uses of such technologies can be found in NFC tags used for physical access and payment,

Figure 4: Examples of down-to-earth high-tech designs. A) Multimedia Wireless Bamboo Keyboard, by ©Green Stationary. B) An NFC Tag in Bamboo by ©Nfctagfactory. C) Human-powered electronic doorlock, by ©iLoq. D) Crank powered quote reader with eInk display, by ©Lundström et al, 2022. E) Still from YouTuber making a Switch Pro Controller out of wood, by ©Peter Knetter 2021. F) Design of a wearable living interface using a personal palette of microbial paints, by ©Bell et al, 2023. G) A moss-covered Smart Wireless Speaker collaboration by The Mossiah & Decibelist, 2024 ©Mossiah. E) Still from animated movie The Wild Robot, showing robot covered in rust and moss ©Universal Pictures, 2024.

ranging from plastic cards to key fobs, to wearable accessories such as bracelets or rings. An important use quality of such 'passive tangibles', is that they do not need to charge nor store energy, although they do require active sensing of other networked devices, e.g., cameras, readers, software and servers, during the moment of use. In Figure 4, we see two examples of passive tangibles in the form of a wooden NFC tag (B), and an electronic door key (C), in which also the lock itself is manually powered by the manual interaction with the key. Another form of passive tangible is the ubiquitous QR code, and last year's TEI conference showcased at least two explorations of such, one printed in mold by [53] and the Dataslip installation [48], in which a simple receipt printout brought light to an everyday, low-tech mode of engaging physically with electronic data. These simplistic, low energy, low key designs point to an aesthetic attitude that does not have in its interest to impress by grandiosity or novelty effect, but by practical, useful and meaningful functionality, caring for its immediate contexts of use as well as to its planetary impact.

Regarding the physical we see a range new electronic products covered in recycled plastic, cardboard, and organic materials like leather and bamboo [78] (See Figure 4a, for just one everyday example). In research, this is mirrored by an extensive range of explorations working with biomaterials, traditional crafts and biophilic forms. A challenge appears to be moving beyond the physical casing to include also aspects of battery, processing and energy consumption. While we have seen that much can be done at the level of surface materials, it needs to be acknowledged that the more crucial environmental challenges remain at the dealing with rare metals required for processing and powering of electronic components, and how these can be ethically produced and deployed.

Beyond the tangible, the enormous amounts of electricity required for e.g. data storage, online media streaming, mining of crypto currencies, and training of machine learning algorithms is a concern regularly brought up in popular media. This is contradicted in design with the concept of 'the cloud' that might on the one hand appear to promise free, unlimited, and permanent storage, but that costs enormous resources to maintain, with damaging effects on both human health and the environment. This failed promise has inspired designs that value the ephemeral as a use quality [17], which we also can see in commercial successes like Snapchat [69]. The ethical implications around the manual labour involved in e.g. the data labelling for generative AI systems, are other important topics in current debate, again grounded in the under-discussed material basis of interactive systems [37].

This theme of energy as an element of eco design also highlights the values and possibilities of working with e.g. manually powered devices. Instead of using energy to e.g. bike to a store to purchase new batteries (and manufacturing new batteries, and building and maintaining electrical power plants), simple electronic systems can be powered by the users' interactions, e.g. the movement of the peppermill remote control [73], by cranking (Figure 4d),or by inserting a physical key to power a doorlock (see Figure 4c). Research on such interactions have demonstrated the need for engaging with functional demonstrators [43], but also a new aesthetic orientation that rethinks energy in interaction, in which every bit of data or processing power is valued. While posing new wicked problems

regarding labour and ergonomics, the experience of manually powering a computer system is not necessarily negative, but appears to potentially provide a fulfilling sense of empowerment [52].

A conclusion here is that eco-design for the context of interactive systems needs to consider electronic components and not least aspects related to energy. With this follows questions of what aspects of an interactive setting that needs to be e.g. connected to the internet, include robotic movement, bright light or play audio, or whether less spectacular solutions may be found more efficient, and thus, more attractive.

3.3 Recycling

The third strategy for sustainable design concerns the development of products so that they, and their components, can be more easily *recycled*, e.g. by making it possible to disassemble and exchange parts. Is it possible to construct a smartphone to last a lifetime? Is it realistic to trust the online services upon which it depends, or even the human practices they aim at supporting, to last forever? If not, the physical as well as interactive components will need to be carefully designed with that insight in mind. While this was for long a completely neglected aspect of high-tech product design, this strategy is undertaken from the physical side by a growing number of manufacturers, most notably Fairphone, as well as by companies that thrive on the repair, upgrading, refurbishing and reselling used devices. This also resonates with the ever-growing stream of research that focuses on care, repair and craft, as a counter-reaction to the innovation-frenzy that previously dominated the interaction design discourse. Examples include Mandel and Ju's material re-use of hoverboards in what they call 'Garbatrage' design [44], but we see this more broadly also in the rise of for instance communal maker spaces and international repair days. Other examples include articulations of wabi-sabi as a design philosophy within HCI [69], and a conceptual refocus in interaction design that emphasise electronic media as materially- and socially grounded. The extensive explorations of hybrid crafting, using electronics in combination with traditional studio crafts, play along the same design interests of material maintenance and re-use.

Important to mention here is the role of digital media for repair-oriented design, and the strong interplay between material crafts and online tutorials, inspirational videos, and examples shared on social media. Note for instance the youtuber sharing his experience of making a Switch game controller out of wood (see Figure 4e), or the amount of Etsy accounts offering custom made organic looking skins for game controllers, in which synthetic versions of natural materials are valued for their visual aesthetics. While such skins might appear as mere surface level 'greenwashing', the possibility to replace a worn surface level material when it gets worn out, instead of replacing the entire gadget, and that we see craftspeople specialising in providing such services, fundamentally reflects a culture in which repairing holds value, allowing for e.g. refurbishing and second hand use of electronic devices [75].

This points to an alternative take on production, assuming a crafting-oriented culture, in which users enthusiastically seem to engage in assembling products at home (as in the Green hide away chair above) and turn online to find out how to repair their broken gadgets. In such a culture, products may be explicitly designed to be recycled, resold, and repaired, rather than merely to satisfy a commercially driven desire for the new and shiny.

3.4 Expand the product's life span

As Verbeek and Kockelkoren [49] discussed already in the late nineties, fully functioning artefacts get thrown away because of a cultural obsession with the new, but also because many modern devices are designed so that they cannot be kept working. While their own design concept addressed this challenge through a rather romantic speculation, they also highlighted how working to expand a product's life span is a problem of culture, which may be hard to address through an individual design project alone. And still, this very same design challenge remains to this day.

However, in a study of a 150 year old Jacquard loom still in use [21] we could see this strategy at work. We could not claim that this was purposefully pursued when the Jacquard loom was originally designed, but, in line with the reasoning of Verbeek and Kockelkoren, its design reflected a cultural climate quite different from ours, and from which current design practices can learn. The loom was entirely made from relatively fragile materials (wood, cardboard and string), that could be easily repaired or replaced. It could be adjusted and modified to fit for changing needs. Most importantly, it was used to produce something still considered valuable – locally produced, high-quality silk textile. It should also be noted that while that loom was still in use, it did so in the context of a museum, and as such was presented as a rarity. Indeed, it is not uncommon with well-kept examples of ceramics, metal works and furniture, seen in long-term, continued, everyday use, and antiquity fairs and vintage markets show that such items do have value. In comparison, contemporary high-tech products are known for their exceptionally short life spans.

We all experience full disk spaces, declining battery life, broken screens, and malfunctioning hardware. Recognizing this is needed to prepare for lasting design, especially if these rely on technologies in constant advancement. An insight from these works is that we cannot assume that hardware platforms, electricity, storage, means of connectivity or that established standards will remain. A well-known strategy for addressing unknown and changing use settings is to design for improvements and adaptations, recognizing that systems must be prepared for continued care.

Importantly, the solution does not seem to come in the form of rocket science type of materials, but rather from down-to-earth common sense use practices of how to care for everyday things. As explained by Lucy Suchman [65], a bridge is only as stable as the practices that uphold it, depending as much on social organizing as on material construction. It is in a similar sense we may read activities like Kombucha making as a relevant material practice within the TEI discourse [8]. Similarly, high-tech products are only as stable as 'we' as a culture are willing to invest in their continuous use, in which it is more practical, economical, and simple, to upgrade and repair than to replace. In this culture, it is no surprise that a design firm such as The Mossiah [79], who designs e.g. moss-covered loudspeakers, also give courses on how to make them, and implicit to this is also teaching how to care for and to repair them. Through a similar concept as the hideaway chair which is a designed object that can be made but not bought, we also see similar

projects presented at TEI that reject not only the status of manufacturing but also decenters the concept of electronic technology, e.g. Oneday Shoes [45]. This points to an aesthetic orientation of the post-industrial ideals, that engages with consumer-oriented design outside of conventional notions of industrial production.

4 Discussion

Bringing design work 'down to earth' could be seen as being about pragmatism, to ground design work on real world practice and material circumstance, about taking design visions down to a level of realism and feasibility. But more fundamentally, or philosophically perhaps, it is also about material entanglements in the world, within the biosphere, and with the living. This thereby brings our perspectives down – all the way – to Earth, beyond immediate contexts of use. Here three main features of this new design direction will be discussed: pragmatism and material frugality, biophilic entanglements, and open, shifting and life-centred values when it comes to aesthetic expressions.

4.1 Pragmatism and Material Frugality

The first theme points to a pragmatic approach that takes design visions to a level of realism and feasibility, recognizing the interconnectedness of human-made designs within the real problems faced in this world. To address these issues, a historical perspective was adopted to analyse contemporary technology, in an attempt to reach a better understanding of both current and emerging design visions. While more speculative approaches may highlight similar design values, a stronger case can be made from studying existing designs, and to learn from examples that were once considered promising but that failed to deliver in the wild. The example from the Minority Report for instance, belonged a family of 'cave-interfaces' in which a person would stand alone in a windowless room to manipulate on-screen information, which – once the technology became commercially available – ultimately didn't play out as an attractive or desired work situation in real life.

The selection of examples of 'down-to-earth' designs in Figure 4 share a simplistic essence of very rudimentary character, far from the wow-factor expressed by the blinking lights and spaceship aesthetics that we have become so accustomed to in the field of 'high tech'. As unsexy and 'uncool' as these examples may seem, they still appear inherently attractive, in the same sense as Cross [13] stated that *'a designer does not use a process that he finds unsympathetic to his own attitudes, or that generates a product which he dislikes' [p. 7].* The fact that contemporary designers, and design researchers, appear to *like* making such low-key, simple, caring and biologically oriented designs is thus an important signal for us to attend to.

Design explorations at TEI has sometimes presented an ideal of moving away from computer screens, aiming for an entirely tactile and physical mode of being with technology. As highlighted above, we should also acknowledge that media content is part of the contemporary blended world, and that media content is speaking, if not about or with the voice of, at least to an audience of live biological beings. The perceived problem of bridging the physical and online spaces is very different now compared to when the field of TEI was originally formed, with new physical interactions not necessarily requiring the design of new physical things. What is experienced in everyday life is an intense blending of screen-based media along with physical activities, in which new physical interactions do not necessarily require new gadgets. Instead new meaningful engagement can occur through existing technologies, for instance an iPad app used to learn how to play on a real physical piano by attending to audio signals and through its screen guiding a learner where and how to place their fingers. This shows physical interactions with and around technology without the default being the making of new physical electronic gadgets. This highlights the role for designers to stay attentive to what makes sense to people and to the environment, and that low-cost, simple designs, often appear more attractive than a more wasteful take on novelty within interactive technology.

This theme addresses the pressing environmental, economic, and political challenges faced by contemporary design practices, particularly concerning electronic waste, but also reduction of unnecessary computational power. The evolving aesthetic directions raise important questions about sustainability and responsible design practices. By focusing on everyday challenges and the implications of design decisions, this approach seeks to foster innovation that is mindful of its environmental impact.

4.2 Biophilic Entanglements

Understanding computer systems as integrated within the biosphere, rather than isolated in a digital void, appears central to the current aesthetic directions discussed in this text. Such design efforts critique the conventional aesthetics of high-tech designs, favoring examples that highlight the complexities of social and material ecosystems. This perspective shifts interaction design from a simplistic one-to-one user-system model to a more nuanced understanding of 'fluid assemblages' that involve multiple contexts, systems, artefacts, and living entities. This reality of contemporary high-tech designs means that any design challenge will always involve considerations of several systems, several people, multiple contexts, and a world in constant change. Importantly, this mesh also includes the 'low-tech', the materialities outside of computers, and nature itself.

The shift from media-technological gadgets, with a primary focus on representing data in new forms, to designs that also engage with the material environment reflects a philosophical understanding but also a desire for the living, as living biological beings. Projects that incorporate biomaterials or hybrid crafting practices may in this sense be appreciated not merely for their novelty but for their aesthetic appreciation of earthly grounding and their systemic implications. While the early TEI exemplars focused on the ambitions to support the connection of sensing human bodies to various interactive technologies, this new stream of works is furthering the ambitions to connect our designs also to the material biosphere we are all depending on. Importantly, these complexities not only concern computational aspects, but also the social and material (eco)systems they affect, and where complexity is not to be seen as a hurdle to overcome or to 'design away', but as an evocative feature of reality to be embraced by designers and researchers alike (see e.g. Figure 4f). This theme is embraced also in popular fiction, such as in the contemporary animated film The Wild Robot [12], in which a case is made of a humanoid machine adapting to wildlife

on a remote island, and towards the end of the film being broken, repaired and covered in rust and moss (see Figure 4h).

Here we should point out that simply including biomaterials or other species (e.g. hooking up a live plant to an electronic system) or an elaborate hybrid crafting practice, can never count as sustainable *as such*. Neither can we assume such experiments to take on a more systemic perspective on interaction than say, an engineering effort aiming to reduce data traffic to minimize electrical consumption. Yet, we can see that these projects are following an *aesthetic appreciation* towards the earthy biology we are all part of, and this is noteworthy. In that case, also biomimicry, or the inclusion of greenery depicted in direct surroundings of technology (see the iLoq in Figure 4c), becomes central to the world aimed for in the design work.

This direction is an attempt to articulate the aesthetics of blending the artificial with the living, in what we read as careful, critical, and circular design practices. Importantly these explorations intersect various fields, including engineering, artistic practice, contemporary philosophy, and science, investigating mechanisms that extend beyond the conventional concerns of state-of-the-art industrial design. Here, the interrogation of design mechanisms transcends traditional industrial practices, encouraging a more nuanced understanding of the interplay between technology and human experience.

4.3 Design Values as Culturally Negotiated

As mentioned above, the historical perspective taken in this essay, in a sense reality-checking design visions from the past, could potentially inform current and future design visions. Importantly, as culture and technical circumstances evolve, so do the practicality of specific design visions and concepts. As commonly noted, Durrel Bishop's iconic marble answering machine of the 1990's [see e.g. 31], was fundamentally tied to a context of using wired telephones and voice-operated answering machines, which from a perspective of today's technological landscape appears rather farfetched however simplistic and practice-grounded it appeared at its time. This also highlights how design visions should be understood to speak more about its current societal concerns, and thereby more than anything working as historical artefacts [1]. Such backwards-looking perspective may help to highlight how design values shift over time, and that tastes, styles and aesthetic norms are matters set in constant cultural negotiation and for which there will always be openings for disagreement. Rather than a monoculture allowing only one visual style or identity, the post-industrial design vision points to a multitude of locally grounded, craft based, and contextually driven practices. Within this plurality, there should be openings for an endless variety of sustainable high-tech designs to come.

Within this context, we could see how Human-Computer Interaction (HCI) is increasingly aligning with the ideals of post-industrial design, perhaps especially within the field of Tangible and Embedded Interaction (TEI). Engagements by media artists and crafts communities have demonstrated how regional crafts and subcultures can inform and enrich product design, allowing for the creation of objects that resonate with diverse aesthetic sensibilities. This, together with recent hype of 'post-digital' manual crafts, highlights the felt experience of being actively engaged, of developing skills, of not just passively receiving the ready-made. Instead of the friction-free vision of ubiquitous computing, or body-less intelligence, the post-industrial vision appears to embrace the experience of manual work, as craftspeople but also as users.

It seems that recent economic, political, and environmental challenges, coupled with a renewed interest in material practices, thereby prompted the emergence of alternative design values. This evolving aesthetic direction influences interactive systems and experiences, with a particularly pressing concern within our field being the negative environmental impact associated with high-tech products, especially regarding electronic waste. Everyday challenges associated with this theme includes ensuring that service upgrades and new product versions do not exacerbate existing environmental problems associated with the design, use, and waste of technology. Through this lens, we can better navigate the complexities of design, fostering practices that are not only innovative but also environmentally responsible, and from which perspective the once 'cool' might now rather be dispelled as 'cold'. In this paper we have combined insights from various historical movements and contemporary design trends (e.g., Solarpunk), to comment on the broader design field, within which TEI is only one small part, but with its focus on the research front of high-tech interactive systems holding the inherent potential to generate constructive impacts and drive significant, long-lasting change.

5 Conclusion

We have here discussed how research teams, design students, artists, makers, and activists, are gathering within the context of TEI to continuously and playfully explore the aesthetic potential of repair, upcycling, repurposing, as well as new technical solutions that support more sustainable electronic products and services. By such experimenting with material forms, technologies, styles, and expressions, the TEI conference's interdisciplinary context provides a very fertile intellectual climate for debate, critique and reflection.

By revisiting notions of post-industrial design in the context of established approaches for sustainable product design, we have analysed how today's design practices are materially linked to specific technological and societal trends. We discussed this through three interpretations of how a sustainable TEI moves away from a '*spaceship aesthetics*', through pragmatism and material frugality, systemic and biophilic design, and through diverse, shifting and plural takes on aesthetic ideals. These three themes collectively highlight the need for an approach to design that prioritizes sustainable design as a culturally grounded engagement with the material world.

To sum up, a large number of projects are currently using material craftsmanship to engage with hopeful visions of a sustainable future, drawing on strong themes in contemporary culture, exposing some of the aesthetic qualities that appear to characterize the experience of sustainably designed products. Importantly, this goes beyond surface materials to focus also on interactive functionality, with a tendency to value a felt experience of rich textures, warmth, brightness, earthy materials and flourishing live plants. To sum this up, it seems this spaceship is turning back to planet Earth.

Acknowledgments

This text is the result of intellectual engagements with colleagues who helped shaping this work, in particular Maria Göransdotter, Christoffel Kuenen, Anna Vallgårda, Andreas Lindegren, and Seda Özçetin. A special thanks also the TEI community whose collective design efforts are used for analysis, and to each of the anonymous reviewers for encouragement and constructive comments. This work was funded by Swedish Research Council, project no: 2019-04826.

References

[1] Jacques. Attali and Jeremy. Leggatt. 2011. A brief history of the future: a brave and controversial look at the twenty-first century.

[2] Martin Avila. 2022. Designing for Interdependence: A Poetics of Relating. https://doi.org/10.24135/link2022.v3i1.185

[3] Karen Barad. 2003. Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter. *Signs: Journal of Women in Culture and Society* 28, 3: 801–831. https://doi.org/10.1086/345321

[4] Jeffrey Bardzell. 2011. Interaction criticism: An introduction to the practice. *Interacting with Computers* 23, 6: 604–621. https://doi.org/10.1016/j.intcom.2011.07.001

[5] Jeffrey Bardzell, Shaowen Bardzell, and Ann Light. 2021. Wanting to live here: Design after anthropocentric functionalism. In *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3411764.3445167

[6] David Batchelor. 2000. *Chromophobia*. Reaktion books.

[7] Patrick Baudisch, Torsten Becker, and Frederik Rudeck. 2010. Lumino: Tangible blocks for tabletop computers based on glass fiber bundles. In *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/1753326.1753500

[8] Fiona Bell, Joshua Coffie, and Mirela Alistar. 2024. Bio-Digital Calendar: Attuning to Nonhuman Temporalities for Multispecies Understanding. In *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction*, 1–15. https://doi.org/10.1145/3623509.3633386

[9] Anthea Black and Nicole Burisch (eds.). 2021. *The New Politics of the Handmade*. Bloomsbury Publishing Plc. https://doi.org/10.5040/9781788316583

[10] Rosi Braidotti. 2016. Posthuman Critical Theory. In *Critical Posthumanism and Planetary Futures*. Springer India, New Delhi, 13–32. https://doi.org/10.1007/978-81-322-3637-5_2

[11] Richard Buckminster Fuller. 1969. *Operating Manual for Spaceship Earth*. Lars Müller Publishers, Zurich, Switzerland.

[12] Chris Sanders. 2024. *The Wild Robot*. Universal Pictures.

[13] Nigel Cross. 1981. The coming of post-industrial design. *Design Studies* 2, 1: 3–7. https://doi.org/10.1016/0142-694X(81)90023-5

[14] Jelle van Dijk, Camille Moussette, Stoffel Kuenen, and Caroline Hummels. 2013. Radical clashes. In *Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction*, 323–326. https://doi.org/10.1145/2460625.2460680

[15] Carl DiSalvo, Phoebe Sengers, and Hrönn Brynjarsdóttir. 2010. Mapping the landscape of sustainable HCI. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1975–1984. https://doi.org/10.1145/1753326.1753625

[16] Tom Djajadiningrat, Ben Matthews, and Marcelle Stienstra. 2007. Easy doesn't do it: skill and expression in tangible aesthetics. *Personal and Ubiquitous Computing* 11, 8: 657–676. https://doi.org/10.1007/s00779-006-0137-9

[17] T Döring, A Sylvester, and A Schmidt. A Design Space for Ephemeral User Interfaces. In *Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction*, 75–82. https://doi.org/10.1145/2460625.2460637

[18] Dale Dougherty. 2012. The Maker Movement. *Innovations: Technology, Governance, Globalization* 7, 3: 11–14. https://doi.org/10.1162/INOV_a_00135

[19] Arturo Escobar. 2018. *Designs for the Pluriverse*. Duke University Press. https://doi.org/10.1215/9780822371816

[20] Kjetil Fallan. 2022. *Ecological by Design*. The MIT Press. https://doi.org/10.7551/mitpress/14518.001.0001

[21] Ylva Fernaeus, Martin Jonsson, and Jakob Tholander. 2012. Revisiting the jacquard loom. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1593–1602. https://doi.org/10.1145/2207676.2208280

[22] Ylva Fernaeus, Jakob Tholander, and Martin Jonsson. 2008. Towards a new set of ideals: Consequences of the practice turn in tangible interaction. In *Proceedings of the International Conference on Tangible and Embedded Interaction (TEI'08)*, 223–230.

[23] Daniel Gagnon-King, Lee Jones, and Sara Nabil. 2023. Interactive Stained-Glass: Exploring a new design space of traditional hybrid crafts for novel fabrication methods. In *Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction*, 1–15. https://doi.org/10.1145/3569009.3572796

[24] Peizhong Gao, Tanhao Gao, Yanbin Yang, Zhenyuan Liu, Jianyu Shi, and Jin Li. 2023. Bamboo Agents: Exploring the Potentiality of Digital Craft by Decoding and Recoding Process. In *Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction*, 1–13. https://doi.org/10.1145/3569009.3572746

[25] Mark Garcia. 2007. Otherwise Engaged: New Projects in Interactive Design. *Architectural Design* 77, 4: 44–53. https://doi.org/10.1002/ad.486

[26] Kaja Seraphina Elisa Hano and Valkyrie Savage. 2024. Hybrid Crochet: Exploring Integrating Digitally-Fabricated and Electronic Materials with Crochet. In *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction*, 1–6. https://doi.org/10.1145/3623509.3635257

[27] Donna J. Haraway. 2016. A Cyborg Manifesto. In *Manifestly Haraway*. University of Minnesota Press, 3–90. https://doi.org/10.5749/minnesota/9780816650477.003.0001

[28] N. Katherine Hayles. 1999. *How We Became Posthuman*. University of Chicago Press. https://doi.org/10.7208/chicago/9780226321394.001.0001

[29] Karey Helms. 2022. A Speculative Ethics for Designing with Bodily Fluids. In *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3491101.3516395

[30] Lars Erik Holmquist. 2023. Bits are Cheap, Atoms are Expensive: Critiquing the Turn Towards Tangibility in HCI. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–8. https://doi.org/10.1145/3544549.3582744

[31] Y Ikeya and B Barati. Designing an Algal Relay Computer: A Critical Orientation in Exploring More-than-Human Temporality. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–6. https://doi.org/10.1145/3544549.3585874

[32] H Ishii and B Ullmer. Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI '97*, 234–241. https://doi.org/10.1145/258549.258715

[33] Hiroshi Ishii, Dávid Lakatos, Leonardo Bonanni, and Jean Baptiste Labrune. 2012. Radical atoms: Beyond tangible bits, toward transformable materials. *Interactions* 19, 1. https://doi.org/10.1145/2065327.2065337

[34] Sylvia Janicki, Alexandra Teixeira Riggs, Noura Howell, Anne Sullivan, and Nassim Parvin. 2024. Sensing Bodies: Engaging Postcolonial Histories through More-than-Human Interactions. In *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction*, 1–15. https://doi.org/10.1145/3623509.3633389

[35] Heekyoung Jung, Shaowen Bardzell, Eli Blevis, James Pierce, and Erik Stolterman. 2011. How Deep Is Your Love: Deep Narratives of Ensoulment and Heirloom Status. 5, 1: 59–71.

[36] Vilma Kankaanpää and Ilyena Hirskyj-Douglas. 2023. Prototyping with Monkeys: Uncovering What Buttons for Monkeys Look Like. In *Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction*, 1–13. https://doi.org/10.1145/3569009.3572735

[37] Shivani Kapania, Alex S Taylor, and Ding Wang. 2023. A hunt for the Snark: Annotator Diversity in Data Practices. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–15. https://doi.org/10.1145/3544548.3580645

[38] Raymund Konigk and Zakkiya Khan. 2015. The ethics of tastemaking: towards responsible conspicuous consumption. 191–199. Retrieved August 2, 2024 from https://research.brighton.ac.uk/en/publications/the-ethics-of-tastemaking-towards-responsible-conspicuous-consump

[39] George Lakoff and Mark Johnson. 1999. *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*. Basic Books.

[40] Brenda Laurel. 2011. Gaian IxD. *Interactions* 18, 5: 38–46. https://doi.org/10.1145/2008176.2008187

[41] Timothy M. Lenton and Bruno Latour. 2018. Gaia 2.0. *Science* 361, 6407: 1066–1068. https://doi.org/10.1126/science.aau0427

[42] Ann Light, Colin M. Gray, Kristina Lindström, Laura Forlano, Dan Lockton, and Chris Speed. 2022. Designing Transformative Futures. https://doi.org/10.21606/10.21606/DRS.2022.896

[43] Anders Lundström and Ylva Fernaeus. 2022. Making Crank-Powered Interactions: Methods, Demonstrators, Materials. In *Designing Interactive Systems Conference*, 913–924. https://doi.org/10.1145/3532106.3533453

[44] Ilan Mandel and Wendy Ju. 2023. Recapturing Product as Material Supply: Hoverboards as Garbatrage. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference*, 564–579. https://doi.org/10.1145/3563657.3596128

[45] Troy Nachtigall, Oscar Tomico, and Ron Wakkary. 2019. Oneday shoes: A maker toolkit to understand the role of co-manufacturing in personalization. In *TEI 2019 - Proceedings of the 13th International Conference on Tangible, Embedded, and Embodied Interaction*. https://doi.org/10.1145/3294109.3295637

[46] Ken Nakagaki, Daniel Fitzgerald, Zhiyao John Ma, Luke Vink, Daniel Levine, and Hiroshi Ishii. 2019. Inforce: Bi-directional "Force" Shape Display For Haptic Interaction. In *TEI 2019 - Proceedings of the 13th International Conference on Tangible, Embedded, and Embodied Interaction*. https://doi.org/10.1145/3294109.3295621

[47] Hye Yeon Nam, JaNiece Campbell, Andrew M. Webb, and Brendan Harmon. 2023. FloraWear: Wearable Living Interface. In *Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction*, 1–15. https://doi.org/10.1145/3569009.3572801

[48] Alejandra Gomez Ortega, Renee Noortman, Jacky Bourgeois, and Gerd Kortuem. 2024. Dataslip: Into the Present and Future(s) of Personal Data. In *ACM International Conference Proceeding Series*. https://doi.org/10.1145/3623509.3633388

[49] P P. Verbeek and Kockelkoren. 1998. The Things That Matter Peter-Paul Verbeek and Petran Kockelkoren. *Design Issues* 14, 3: 28–42.

[50] Victor Papanek. 1972. *Desgin For The Real World*.

[51] Marianne Graves Petersen, Ole Sejer Iversen, Peter Gall Krogh, and Martin Ludvigsen. 2004. Aesthetic interaction. In *Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques*, 269–276. https://doi.org/10.1145/1013115.1013153

[52] James Pierce and Eric Paulos. 2010. Materializing energy. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems*, 113–122. https://doi.org/http://doi.acm.org/10.1145/1858171.1858193

[53] Valentin Postl, Wolfgang Schwendtbauer, Thomas Preindl, and Kathrin Probst. 2024. Mold Printer: Creating Living Self-Revealing Artworks. In *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction*, 1–12. https://doi.org/10.1145/3623509.3633396

[54] Johan Redström and Heather Wiltse. 2019. *Changing Things*. Bloomsbury Publishing Plc. https://doi.org/10.5040/9781350004368

[55] Juan David Reina-Rozo. 2021. Art, Energy and Technology: the Solarpunk Movement. *International Journal of Engineering, Social Justice, and Peace* 8, 1: 55–68. https://doi.org/10.24908/ijesjp.v8i1.14292

[56] Takumi Saeki and Kazuhiro Jo. 2024. '𐤉'(1926) by BioLuminescent Bacteria. In *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction*, 1–3. https://doi.org/10.1145/3623509.3635320

[57] Michael Scott. 2017. 'Hipster Capitalism' in the Age of Austerity? Polanyi Meets Bourdieu's New Petite Bourgeoisie. *Cultural Sociology* 11, 1: 60–76. https://doi.org/10.1177/1749975516681226

[58] Giulia Sesini, Cinzia Castiglioni, and Edoardo Lozza. 2020. New Trends and Patterns in Sustainable Consumption: A Systematic Review and Research Agenda. *Sustainability* 12, 15: 5935. https://doi.org/10.3390/su12155935

[59] Ashley Shew. 2023. *Against Technoableism: Rethinking Who Needs Improvement*. W. W. Norton & Company.

[60] Shu Hung and Joseph Magliaro. 2010. *By Hand: The Use of Craft in Contemporary Art*. Princeton Architectural Press. Retrieved from http://www.amazon.com/By-Hand-The-Craft-Contemporary/dp/1568989423

[61] Richard Shusterman. 2011. Somaesthetics: Thinking Through the Body and Designing for Interactive Experience. In *Encyclopedia of Human-Computer Interaction*, Mads Soegaard and Rikke Friis Dam (eds.). The Interaction Design Foundation. Retrieved from http://www.interaction-design.org/encyclopedia/somaesthetics.html

[62] V Šimbelis, A Lundström, K Höök, J Solsona, and V Lewandowski. Metaphone: machine aesthetics meets interaction design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14). Association for Computing Machinery*, 1–10. https://doi.org/10.1145/2556288.2557152

[63] Steven Spielberg. 2002. *Minority Report*. 20th Century Fox.

[64] L Suchman. 1987. *Plans and Situated Actions*. Cambridge University Press.

[65] Lucy Suchman. 2000. Organizing Alignment: A Case of Bridge-building. *Organization* 7, 2. https://doi.org/10.1177/135050840072007

[66] Joshua Tanenbaum, Karen Tanenbaum, and Ron Wakkary. 2012. Steampunk as design fiction. *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems - CHI '12*: 1583. https://doi.org/10.1145/2207676.2208279

[67] Cameron Tonkinwise. 2014. Design Away. In *Design as Future-Making*. Bloomsbury Publishing Plc, 198–213. https://doi.org/10.5040/9781474293907-0022

[68] Vasiliki Tsaknaki. 2017. Making preciousness: Interaction design through studio crafts. KTH Royal Institute of Technology, Stockholm.

[69] Vasiliki Tsaknaki and Ylva Fernaeus. 2016. Expanding on Wabi-Sabi as a Design Resource in HCI. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 5970–5983. https://doi.org/10.1145/2858036.2858459

[70] B Ullmer, O Shaer, A Mazalek, and C Hummels. *Weaving Fire into Form: Aspirations for Tangible and Embodied Interaction*. Morgan & Claypool.

[71] John Underkoffler. 1997. Antisedentary Beigeless Computing. *Personal Technologies* 1, 1: 28–40. https://doi.org/10.1007/BF01317886

[72] Anna Vallgårda and Ylva Fernaeus. 2015. Interaction Design as a Bricolage Practice. In *Proceedings of the International Conference on Tangible, Embedded and Embodied Interaction (TEI '15)*, 173–180. https://doi.org/10.1145/2677199.2680594

[73] Nicolas Villar and Steve Hodges. 2010. The peppermill. In *Proceedings of the International Conference on Tangible, Embedded and Embodied Interaction TEI '10*, 29. https://doi.org/10.1145/1709886.1709927

[74] Ron Wakkary. 2021. *Things We Could Design*. The MIT Press. https://doi.org/10.7551/mitpress/13649.001.0001

[75] T. Wallner, L. Magnier, and R. Mugge. 2019. Can refurbished products feel like antiques? The role of the neoretro design style on consumers' evaluation of refurbished products. In *3rd PLATE 2019 Conference*, 825–834.

[76] Rhys Williams. 2019. 'This Shining Confluence of Magic and Technology': Solarpunk, Energy Imaginaries, and the Infrastructures of Solarity. *Open Library of Humanities* 5, 1. https://doi.org/10.16995/olh.329

[77] Peter Wright, Jayne Wallace, and John McCarthy. 2008. Aesthetics and experience-centered design. *ACM Transactions on Computer-Human Interaction* 15, 4: 1–21. https://doi.org/10.1145/1460355.1460360

[78] Green Stationery, Green Office, Recycled Paper. Retrieved November 18, 2024 from https://www.greenstat.co.uk/

[79] The Mossiah - All Things Moss. Retrieved November 18, 2024 from https://themossiah.sg/