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COMMENTARIES

# Designing Postdigital Futures: Which Designs? Whose Futures?

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## Introduction

Designing technology for education is never only a problem-solving practice. It is always already about creating spaces for inherently political and affective socio-technical future relations (Light and Akama 2014). These can point towards 'big futures', i.e. radical ruptures and epochal change, or 'little futures', emergent processes in mundane, everyday practices (Michael 2017; Pink et al. 2022). Beginning with these assumptions, this commentary identifies key issues for concern at the nexus of futures, education, and design in the postdigital condition, in which digital technologies are embedded throughout educational spaces, but no longer conceived as a panacea for socio-economic-ecological ills. Instead, power relations and tensions lie at the heart of assumptions about designing futures. In the midst of the inequitable 'planetary ruins' in which we now live, learn, and teach (Tsing et al. 2017), we need new narratives about the future (Facer 2019).

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Exploring these old and new narratives, this commentary suggests that practitioners, researchers, and others impacted by sociotechnical systems need to design futures and think about how to design futures that matter to them; otherwise, they (we) hand over design decisions to dominant actors. These design decisions impact not only technicalities, but also how education — and thus the future — will be configured. Yet there is no unanimous understanding of what 'good design' or a 'desirable future' looks like. As soon as 'we' begin to design, tensions and struggles unfold. This commentary fundamentally questions whether educational futures can be designed at all, given that education is inherently uncertain and beautifully risky (Biesta 2013). Tangled up in our own contradictions, we (the authors of this commentary) simultaneously question a sense of design optimism while also optimistically designing educational interventions and research.

Against this background, this commentary highlights three issues: (1) What possibilities emerge from decentring an engineering approach to designing postdigital futures? We explore alternative approaches to design that avoid the engineering logic predominant in education today. (2) What drives innovation in design? Drawing on feminist approaches to innovation, we reflect on the role of care in postdigital futures and extend care to a damaged planet. (3) Where are the limits of design in education? A critique of design practices means turning critical analysis onto the very concept of design and interrogating the limits of design.

Overall, the commentary illustrates how 'design' is contested today, with significant implications for the future. Far from a solutionist Silicon Valley approach to designing digital futures, we flag a 'postdigital' design that assumes — as does postdigital research more broadly (Jandrić et al. 2018; Knox 2019; Macgilchrist 2021) — that realities are messy, muddy, noisy; that nothing is purely, smoothly digital; and that the very idea of 'designing futures' signals how design is entangled with epistemological and ontological groundings, with political and affective relations, with historical legacies of exclusion and oppression, and with sociomaterial and planetary impact.

## What Possibilities Emerge from Decentring an Engineering Approach to Designing Postdigital Futures?

Design has been conceptualised as a methodologically driven and strictly controlled process of engineering as well as a creative and aesthetic practice. Engineering approaches have made inroads into educational research and practice. For instance, design-based research (a scholarly approach to designing interventions and building theory) and design thinking (a practice-based method) both generally reproduce an engineering approach. They view design as a well-structured process; the design problem is assumed to be given; the goal is to engineer a solution to the problem. Idea generation is explicitly or implicitly understood as a rational, cognitive process. 'Designerly ways of knowing' and a long history of design theory (Cross 2007), however, differ radically from these engineering approaches. Design as 'grappling with the not-yet-known' (Richter et al. 2015) is a socially

and materially mediated process where problem and solution are co-evolutionarily entangled (Gedenryd 1998).

When we recognise this, and recognise 'that in designing tools we are designing ways of being' (Winograd and Flores 1986: xi), design becomes ontological. Ontological design has been described as a 'way of characterising the relation between human beings and lifeworlds' (Willis 2006: 70). Design is then far more fundamental to being human than is often thought, since people are constantly planning and prefiguring their actions, even if these plans do not turn into actions or effects as planned (Suchman 2007; Willis 2006). If design is ontological in that it is a 'conversation about possibilities' (Escobar 2018: 110) then designing EdTech is ontological in that it opens up — beyond ways of learning and ways of teaching — possible or impossible ways of doing, ways of being, and ways of desiring.

Design practices shape and configure human and more-than-human relations, practices, identities, values, ideas, and materialities (e.g. Binder et al. 2011; Ehn 2008). Not only technologies and interfaces, but sociotechnical systems, behaviour, attitudes, bodies, and even the plastic brain become subject to design. Neurotechnology in education becomes part of bio-socio-technical assemblages in efforts to design, govern, and enhance societies (Williamson, 2019). The interplay of biological, technical, and social dynamics is instrumentally managed to expand human potential in complex processes of transformation (see Peters et al. 2022). So our designs design us, by creating structures and materialities within which we act. In this sense, a key tenet of ontological design is that 'we design our world, while our world acts back on us and designs us' (Willis 2006: 70). A corollary of such a tenet is that design is, relationally speaking, intrinsically posthuman (cf. Bennet 2004; Bayne 2015).

Theories of power, knowledge, and justice also become essential to understanding design in education. For Sasha Costanza-Chock and collaborators from the Design Justice Network, for instance, the theory and practice of design justice 'urges us to explore the ways that design relates to domination and resistance' (Costanza-Chock 2020: 20). Inspired by feminist thought and intersectional feminism (e.g. Crenshaw 1991), design justice aims to dismantle the histories of oppressive systems of capitalism, white supremacy, ableism, heteropatriarchy, and settler colonialism within which design continues to unfold. 'Respectful design' incorporates Indigenous ways of learning and being, and decentres not only engineering approaches to design, but also humans, in order to prioritise relations among humans and more-than-humans, increasing human accountability in our social and ecological relations (Tunstall 2017). 'Transformative justice' aims to avoid reproducing and replicating already existing structural inequalities in technology, especially in health care and education (Greene 2021). The 'matrix for convivial technology' emphasises the interdependence and co-evolution of individuals, social networks, technologies, and the planet (Vetter 2018, see also Selwyn 2023).

Participatory design, co-creation, and co-design have also become widely used concepts, sometimes referring to the inclusion of 'customers' in design processes, sometimes to the idea that 'citizens' should be involved in design processes, or, more decisively, that traditionally minoritized communities should be designing their own futures (e.g. Costanza-Chock 2020; D'Ignazio and Klein 2020; Jarke 2021).

The 'necessity and creativity of ongoing practices of design-in-use' has illustrated that design does not stop at the moment the artefact is produced, but that the configuration of these artefacts continues across the sites of their use (Suchman 2007: 278). This shifts traditional hierarchies and power dynamics, as it challenges whose knowledge and expertise are valued and decentres the position of a 'professional' designer to those affected by designs.

In this respect, design practices can be enacted otherwise and provide means and processes of questioning and transforming legacy (institutionalised) structures and categories through creativity and imagining. Educational technologies in education are seen as operating in the 'mud' and 'noise' of the 'scrappy realities' of everyday (postdigital) educational practices (Jandrić et al. 2018; Macgilchrist 2021; Selwyn and Jandrić, 2020). Instead of following a solutions-oriented engineering logic, the approaches mentioned in this section ask: who benefits, who is harmed, and who participated in this design process or that designed product (Costanza-Chock 2020: 134)? Whose designs design whose worlds?

As soon as we do design in (educational) research, theories of design become as important as methodological issues. This commentary seeks to stimulate critical reflection on design and the (histories of) design practices undergirding educational futures, which are often not made explicit. We need studies on the paradoxes of design and the power of design in education. We need to have conversations about studies emerging from different epistemological traditions, to capture the possibilities and impossibilities of designing postdigital futures.

## What Drives Innovation in Design?

There is an inherent tension between design's ambition to imagine alternative futures and the long history of colonising and defuturing effects implicated in current design practices. Design is inevitably a site for the imagination, where speculation enmeshes with artefacts and narratives about change and innovation (Dunne and Raby 2013). Attentive to who or what counts as a designer and who we design for, scholars in education also need to consider through which narratives and imaginaries innovative technologies are designed and which stories they in turn tell about education (Cerratto Pargman et al. 2022).

What counts as 'innovative' design has long been associated with patriarchal capitalist modernity (Escobar 2018: 3), and an understanding of human evolution that centres around practices and tools associated with dominance, competition, and fighting. In her feminist account of human evolution, Elizabeth Fisher (1979) critically examines the male gaze on innovation. She asks why nature is understood as something that needs to be conquered, possessed, or dominated and questions the commonplace narrative that defines men and their hunting tools as sole human inventors. Rather, Fisher argues, humans did not first stand 'in order to use tools for hunting … [but] in order to have their hands free for gathering and carrying'. Instead of bow and arrow, she argues, the earliest cultural invention was 'a container to hold gathered products and some kind of sling or net carrier' (Fisher 1979: 59). Building on Fisher's ideas, feminist thinker and science fiction writer,

Ursula K. Le Guin argued that the focus on dominant behaviour and male power as key drivers for innovation is partly based on the ways in which these activities can be told as heroic stories. She exemplifies this in a fictional account of Oob and Boob, two neolithic hunters:

> It is hard to tell a really gripping tale of how I wrested a wild-oat seed from its husk, and then another, and then another, and then another … it does not compare, it cannot compete with how I thrust my spear deep into the titanic hairy flank while Oob, impaled on one huge sweeping tusk, writhed screaming, and blood spouted everywhere in crimson torrents, and Boob was crushed to jelly when the mammoth fell on him as I shot my unerring arrow straight through eye to brain. That story not only has Action, it has a Hero. Heroes are powerful. Before you know it, the men and women in the wild-oat patch and their kids and the skills of the makers and the thoughts of the thoughtful and the songs of the singers are all part of it, have all been pressed into service in the tale of the Hero. But it isn't their story. It's his. (Le Guin 1989: 165f)

The ways in which we tell stories about digital innovation in education are not very different. For example, Juliane Jarke and Felicitas Macgilchrist (2021) demonstrate how the data dashboards of learning analytics platforms tell powerful stories about heroes, danger, and victims. They have their own temporality and create and configure emotional responses. Audrey Watters (2020) indicates the legacy of Skinner's behaviourist teaching machines when other technologies are introduced through heroic actions. They are '[f]or your own good', '[f]or the good of the global community', '[f]or the sake of the children' (Watters 2020). Stories of everyday patterns of living with technologies enable other ways of seeing and feeling data-driven life (Singh et al. 2022). In other words:

> It matters what matters we use to think other matters with; it matters what stories we tell to tell other stories with; it matters what knots knot knots, what thoughts think thoughts, what descriptions describe descriptions, what ties tie ties. It matters what stories make worlds, what worlds make stories. (Haraway 2016: 12)

Thus, it also matters what designs design designs.

In framing and understanding technologies for education along narratives of power, dominance, and conquest, we leave no room for stories about those practices that are fundamental for our individual and collective well-being. Practices of caring and nurturing that value living and communal doings are backgrounded when innovation and design are obsessed with efficiency, scaling-up, and optimisation. Feminist thinkers have long attended to the dynamics that invisiblise and devalue care work, e.g. in the sciences (Star 1995), in education (Beck and Cassidy 2019; Damarin 1994; Noddings 2015; Atenas et al. 2022) and society at large (Tronto 2020; Puig de la Bellacasa 2017), or the (im)possibilities of careful arrangements and care practices through, with and in opposition to technologies (Zakharova and Jarke 2022; Criado and Rodríguez-Giralt, 2016). Rather bleakly, the Care Collective states that 'our world is one in which carelessness reign' and asks us to imagine

what would happen 'if we were to begin instead to put care in the very centre of life' (Chatzidakis et al. 2020: 5). Centring care in futures imaginaries refers to our 'individual and common ability to provide the political, social, material, and emotional conditions that allow the vast majority of people and living creatures on this planet to thrive—along with the planet itself' (Chatzidakis et al. 2020: 6).

This need for careful design and design with care has also received increased attention in the design and human–computer interaction communities (e.g. Jönsson et al., 2019; Toombs et al. 2018; Salamanca and Geppert 2020) which argue that we need to perform a shift from 'design things' to 'design and care' (Puig de la Bellacasa 2017). They recognise that the dominant contemporary understanding of design and innovation is fundamentally flawed. Bender et al. (2021), for instance, consider the planetary damage and social injustice of large-scale language models (NLP). They calculate the environmental impact of these models and ask: 'How big is too big?' Residents in the Maldives or Sudan will, they argue, be disproportionately affected by climate change and pay the 'environmental price of training and deploying ever larger English LMs [language models], when similar large-scale models are not being produced for Dhivehi or Sudanese Arabic' (Bender et al. 2021: 613). We hence need a range of transition narratives/visions that can problematise classic perspectives on 'design', account for the planetary damage that may be caused and generate alternatives. In such alternatives, we view practices and narratives of caring and nurturing (rather than striving for ever bigger, more efficient, or competitive designs) as part and parcel of a 'transition imaginary' (Escobar 2018: 143) towards a sustainable and more just world.

This commentary calls for transition narratives in designs for education and encourages explorations of feminist ideas of care-ful innovation. Stories move us to reconsider what other worlds are possible if we understand the work of innovating educational technologies around notions of care and nurturing — which is done by humans, non-humans, and more-than-humans — rather than competition, scaling-up, and optimisation. This means radically transforming the ways in which we plan, design, and create our postdigital futures. Instead of framing educational problems in ways that can be addressed and solved by technologies (and in so doing, submitting to technological solutionism where for every social problem there exists at least one technical solution), scholars and designers in education need to come together and ask: In what world do we want to live? What values guide our practices and institutions? What kinds of relationships do we want to nourish? What education do we need in the midst of a climate emergency? What education do we desire for postdigital futures?

## Where Are the Limits of Design Practices in Education and Educational Technology?

An interest in exploring the limits of design leads us to look at the relation between design and (educational) technology, which is still not clear (Dorst and Vermaas 2005; Gero and Kannengiesser 2002). Examining, for instance, the historical materialities of the digital, we wonder how open design practices are for postdigital futures, if today's digital infrastructures, which were designed in the past, foreclose

and determine many design possibilities. Software programming, for example, never really starts from scratch but uses existing libraries, programming frameworks, computational models, standards, and algorithms which are material ways of conceptualising the world (e.g. object-oriented programming, which assumes identifiable objects). These legacy infrastructures are never — despite providers' claims to the contrary — 'neutral': they afford and disafford certain ways of designing for postdigital futures as we experience path dependencies emerging from decisions made in the past about the sociotechnical worlds in which we live and the futures we hope to attain (Seeman et al. 2022). Just as existing social milieus structure ways of living, technical milieus also pre-exist any design process and prefigure it (Floyd 1997; Rieder 2020; Richter 2022).

The implications of legacy infrastructure for design practices in turn have implications for responsibility, which often remains undefined. If software engineers, for instance, invite users to co-design, who is responsible for the final product as the engineers 'collect requirements' and translate them into specifications, formal modes, and programming? Can software engineers abdicate responsibility to users? Or, if we consider posthuman, sociomaterial, postdigital configurations: are programming frameworks, metadata standards, and modelling languages responsible as *they* prefigure and limit any future design attempts? Is the person who set the objectives and (did not fully and correctly) articulate the requirements responsible? Is it the user who completes the design in use? Or is it neither the user nor the designer, but the existing infrastructure which pre-figured the process? How does responsibility shift when data emerge from social systems that are then used to 'train' machine-learning models? Who is legitimated to draw political decisions for far-reaching infrastructure projects with effects on learning and education? Given the (dis)affordances of legacy infrastructures, perhaps it is not going too far to claim that no-one 'designs' technologies or educational interventions from scratch today. Key design decisions were made in the past.

But, more fundamentally, we could ask if the future can be designed at all. The design theories and designerly ways of knowing mentioned above foreground the ontological indeterminacy of the present. In this view, neither powerful actors nor participatory grassroots processes can 'design' (as in programme, configure, foresee, plan, anticipate) the future. Whatever is designed unfolds in unforeseen ways. Any solution or technology must fail in its ambition to solve a problem. Does the word 'design' invite us — insidiously — to imagine that we have more control over the future than is possible? But taking up the challenge to design is fundamentally political: if those affected by design do not also design, then the world is shaped without them (without us). Ruha Benjamin wonders, however, if 'design' is the best word for critical projects aiming towards justice, liberation, and change. If 'design is a colonizing project' in that the concept is used to describe 'any and everything', then it is precisely the elevated social status assigned to designers that in turn diminishes other forms of human activity (Benjamin 2019: 176).

This commentary invites scholars to deeply interrogate not only the sociocultural aspects, which remain predominant in many studies but also the material aspects of sociotechnical worldbuilding. How can studies draw on posthuman or postdigital theorising to engage with the histories of decisions built into standards, frameworks, etc. used today

to design futures? With regard to the 'design of everything', be it (learning) experience design or cultural engineering, postdigital design approaches must go beyond doing and reflecting on design and ask what should *not* be left to design. What role can design have or not have, in a world of crises, in which injustice is palpable, global access to essential infrastructures is uneven, and the development and use of technologies within capitalist logics are stripping the planet of resources (Crawford 2021)?

## Concluding Thoughts

Design is always future-oriented. Debates about education are often future-oriented. Technology comes with promises for better futures. But the 'future' has not always been an explicit matter of concern in research on design, education, and technology. Why have researchers turned with such force towards futurity now? Perhaps it is as simple as the perception that we are living in a crisis-ridden world. Or the awareness that narratives about the future are owned by actors with vested interests in retaining the status quo of profit-oriented domination and oppression (Williamson 2022).

With this awareness comes the need to critically unpack assumptions about how we design for education, for whom, and by whom, as well as how dominant EdTech narratives conquer design spaces for education. Paying attention to designing postdigital futures is an opportunity to analyse dominant designs and narratives and make space for envisioning other ways to do design in EdTech and to shape new narratives about education, such as transition narratives and future-justice stories.

Our priorities in this commentary suggest that these new stories look beyond the dominant grand techno-solutionist narratives about universal high-tech solutions, global demographic trends, or illusions of efficiency and progress. Instead, they tell powerful stories encompassing the locally situated values, worldviews, institutions, structures, and practices by which people want to live (Pink et al. 2022; see also Von Stackelberg and McDowell 2015; Machado de Oliveira 2021). These new narratives include attending to careful design, redesigning institutions to build on community solidarity, and reflecting on the undesignable. Tiny, situated narratives about emergent little, local futures support actions in 'the pursuit of the possible rather than the probable' and allow the democratisation of design decisions (McQuillan 2022: 136).

Beyond engineering approaches to design, the 'postdigital' of designing futures orients to the messy realities and everyday injustices of our present. If designing sociotechnical artefacts is always already designing relations, the relations within educational practice are at stake. Design theories — often unreflected — impact design decisions. Narratives about designs impact what can be thought about design, and what is seen as desirable design. Legacy infrastructures impact design decisions about future possibilities. To rephrase key questions from this article: Which designs design which worlds? Whose designs are we talking about? And whose futures are at stake?

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## References

Atenas, J., Beetham, H., Bell, F., Cronin, C., Vu Henry, J., & Walji, S. (2022). Feminisms, technologies and learning: continuities and contestations. *Learning, Media and Technology*, *47*(1), 1–10. https://doi.org/10.1080/17439884.2022.2041830.

Bayne, S. (2015). Teacherbot: interventions in automated teaching. *Teaching in Higher Education*, *20*(4), 455–467. https://doi.org/10.1080/13562517.2015.1020783.

Beck, K., & Cassidy, W. (2019). Teaching in difficult times: The promise of care ethics. In A. Jule (Ed.), *The compassionate educator: Understanding social issues and the ethics of care in Canadian schools* (pp. 31-50). Toronto: Canadian Scholars Press.

Benjamin, R. (2019). *Race After Technology: Abolitionist Tools for the New Jim Code.* Cambridge, UK and Medford, MA: Polity.

Bender, E. M., Gebru, T., McMillan-Major, A., & Shmitchell, S. (2021). On the dangers of stochastic parrots: Can language models be too big? In L. Irani, S. Kannan, M. Mitchell, & D. Robinson (Eds.), *Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency* (pp. 610–623). New York: Association for Computing Machinery. https://doi.org/10.1145/3442188.3445922.

Bennett, J, (2004). The force of things: Steps toward an ecology of matter. *Political Theory, 32*(3), 347–372. https://doi.org/10.1177/0090591703260853.

Biesta, G. (2013). *The beautiful risk of education*. London: Paradigm Publishers.

Binder, T., De Michelis, G., Ehn, P., Jacucci, G., & Linde, P. (2011). *Design things*. Cambridge, MA: MIT Press.

Cerratto Pargman, T., Lindberg, V., & Buch, A. (2022). Automation is coming! Exploring future(s)-oriented methods in education. *Postdigital Science and Education*. https://doi.org/10.1007/s42438-022-00349-6.

Chatzidakis, A., Hakim, J., Litter, J., Rottenberg, C., & Segal, L. (2020). *The care manifesto: The politics of interdependence*. London: Verso Books.

Costanza-Chock, S. (2020). *Design justice: Community-led practices to build the worlds we need*. Cambridge, MA: MIT Press.

Crawford, K. (2021). *Atlas of AI*. New Haven, CT: Yale University Press.

Crenshaw, K. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review, 43*(6), 1241–1299. https://doi.org/10.2307/1229039.

Criado, T. S., & Rodríguez-Giralt, I. (2016). Caring through design? En torno a la silla and the 'joint problem-making' of technical aids. In C. Bates, R. Imrie, & K. Kullman (Eds.), *Care and design: Bodies, buildings, cities* (pp.198–218). Hoboken, NJ: Wiley-Blackwell.

Cross, N. (2007). *Designerly ways of knowing*. Basel: Birkhäuser.

Damarin, S. K. (1994). Equity, caring, and beyond: Can feminist ethics inform educational technology? *Educational Technology, 34*(2), 34–39.

D'Ignazio, C., & Klein, L. F. (2020). *Data feminism*. Cambridge, MA: MIT press.

Dunne, A., & Raby, F. (2013). *Speculative everything: design, fiction, and social dreaming*. Cambridge, MA: MIT Press.

Dorst, K., & Vermaas, P. E. (2005). John Gero's function-behaviour-structure model of designing: A critical analysis. *Research in Engineering Design, 16,* 17–26. https://doi.org/10.1007/s00163-005-0058-z.

Ehn, P. (2008). Participation in design things. In J. Simonsen & T. Roberston (Eds.), *Participatory design conference (PDC), Bloomington, Indiana, USA (2008)* (pp. 92-101). Indianapolis, IN: Indiana University Press.

Escobar, A. (2018). *Designs for the pluriverse*: *Radical interdependence, autonomy and the making of worlds*. Durham, NC: Duke University Press.

Facer, K. (2019). Storytelling in troubled times: What is the role for educators in the deep crises of the 21st century? *Literacy, 53*(1), 2–13. https://doi.org/10.1111/lit.12176.

Fisher, E. (1979). *Woman's creation: Sexual evolution and the shaping of society*. New York: MacGraw-Hill.

Floyd, C. (1997). Autooperationale Form und situiertes Handeln. In C. Hubig (Ed.), *Cognitio humana - Dynamik des Wissens und der Werte. XVII. Deutscher Kongreß für Philosophie Leipzig 23.–27. September 1996, Kongreßband: Vorträge und Kolloquien* (pp. 237–252). Berlin: Akademie Verlag. https://doi.org/10.1515/9783050073651-023.

Gedenryd, H. (1998). How designers work: Making sense of authentic cognitive activities. PhD-thesis. Lund: Lund University. https://lup.lub.lu.se/search/publication/d88efa51-c2f9-4551-a259-00bd36fe8d03. Accessed 20 December 2022.

Gero J. S., & Kannengiesser, U. (2002). The situated function-behaviour-structure framework. In J. S. Gero (Ed.), *Artificial intelligence in design* (pp. 89–104). Amsterdam: Kluwer. https://doi.org/10.1007/978-94-017-0795-4_5.

Greene, N. (2021). Epistemic injustice and transformative justice. *Southwest Philosophy Review, 37*(1), 35–43. https://doi.org/10.5840/swphilreview20213715.

Haraway, D. J. (2016). *Staying with the trouble: Making kin in the chthulucene*. Durham, NC: Duke University Press.

Jandrić, P., Ryberg, T., Knox, J., Lacković, N., Hayes, S., Suoranta, J., Smith, M., Steketee, A., Peters, M., McLaren, P., Ford, D. R., Asher, G., McGregor, C., Stewart, G., Williamson, B., & Gibbons, A. (2018). Postdigital dialogue. *Postdigital Science and Education, 1*(1), 163–189. https://doi.org/10.1007/s42438-018-0011-x.

Jarke, J. (2021). *Co-creating digital public services for an ageing society. Evidence for user-centric design*. Cham: Springer. https://doi.org/10.1007/978-3-030-52873-7.

Jarke, J., & Macgilchrist, F. (2021). Dashboard stories: How narratives told by predictive analytics reconfigure roles, risk and sociality in education. *Big Data & Society*, *8*(1). https://doi.org/10.1177/20539517211025561.

Jönsson, L., Light, A., Lindström, K., & Ståhl, Å. (2019). How can we come to care in and through design? In T. Mattelmäki, R. Mazé, & S. Miettinen (Eds.), *Nordes 2019: Who Cares?, 3 - 6 June.* Espoo, Finland: Aalto University. https://doi.org/10.21606/nordes.2019.011.

Knox, J. (2019). What does the 'postdigital' mean for education? Three critical perspectives on the digital, with implications for educational research and practice. *Postdigital Science and Education, 1*(2), 357–370. https://doi.org/10.1007/s42438-019-00045-y.

Le Guin, U. K. (1989). *Dancing at the edge of the world. Thoughts on words, women, places*. New York: Grove Press.

Light, A., & Akama, Y. (2014). Structuring future social relations: The politics of care in participatory practice. In O. S. Iversen (Ed.), *Proceedings of the 14th Participatory Design Conference on Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium Papers, and Keynote Abstracts - PDC '14 - Volume 2* (pp. 151–160). New York: Association for Computing Machinery. https://doi.org/10.1145/2661435.2661438.

Macgilchrist, F. (2021). Theories of postdigital heterogeneity: Implications for research on education and datafication. *Postdigital Science and Education, 3*(3), 660–667. https://doi.org/10.1007/s42438-021-00232-w.

Machado de Oliveira, V. (2021). *Hospicing modernity: Facing humanity's wrongs and implications for social activism*. Berkeley, CA: North Atlantic Books.

McQuillan, D. (2022). *Resisting AI: An anti-fascist approach to artificial intelligence.* Bristol: Bristol University Press.

Michael, M. (2017). Enacting Big Futures, Little Futures: Toward an ecology of futures. *The Sociological Review*, *65*(3), 509–524. https://doi.org/10.1111/1467-954x.12444

Noddings, N. (2015). Care ethics and 'caring' organizations. In D. Engster & M. Hamington (Eds.), *Care ethics and political theory* (pp. 72–84). Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198716341.003.0005.

Peters, M. A., Jandrić, P., & Hayes, S. (Eds.). (2022). *Bioinformational philosophy and postdigital knowledge ecologies*. Cham: Springer. https://doi.org/10.1007/s42438-022-00329-w.

Pink, S., Berg, M., Lupton, D., & Ruckenstein, M. (2022). *Everyday automation: Experiencing and anticipating emerging technologies*. London: Routledge.

Puig de la Bellacasa, M. P. (2017). *Matters of care: Speculative ethics in more than human worlds*. Minneapolis, MN: University of Minnesota Press.

Richter, C., Allert, H., Albrecht, J., & Ruhl, E. (2015). Grappling with the not-yet-known. In O. Lindwall, P. Häkkinen, T. Koschman, P. Tchounikine, & S. Ludvigsen (Eds.), *Exploring the material conditions of learning: The Computer supported Collaborative Learning (CSCL) Conference 2015, Volume 1* (pp. 284–291). The International Society of the Learning Sciences.

Richter, C. (2022). Soziale Medien und Digitale Technologien. In N. Böhnke, C. Richter, C. Schröder, M. Ide, & H. Allert (Eds.), *Spuren digitaler Artikulation—Interdisziplinäre Annäherungen an Soziale Medien als kultureller Bildungsraum* (pp. 171–223). Bielefeld: transcript Verlag.

Rieder, B. (2020). *Engines of order: A mechanology of algorithmic techniques*. Amsterdam: Amsterdam University Press. https://doi.org/10.1515/9789048537419.

Salamanca, J., & Geppert, A. (2020). 'Thinking with' care in PD: Toward generating research programs and practices to foster 'participations otherwise'. In C. Del Gaudio, L. Parra, S. Agid, C. Parra, G. Poderi, D. Duque, L. Villezcas, A. Botero, F. César Londoño, & P. Escandón (Eds.), *Proceedings of the 16th Participatory Design Conference 2020 - Participation(s) Otherwise - Volume 2* (pp. 209–212). New York: Association for Computing Machinery. https://doi.org/10.1145/3384772.3385173.

Seeman, M., Macgilchrist, F., Richter, C., Allert, H., & Geuter, J. (2022). *Konzeptstudie. Werte und Strukturen der Nationalen Bildungsplattform*. Berlin: Wikimedia Deutschland e. V. https://www.wikimedia.de/wp-content/uploads/2022/11/Konzeptstudie-Werte-und-Strukturen-der-Nationalen-Bildungsplattform.pdf. Accessed 20 December 2022.

Selwyn, N. (2023). Digital degrowth: toward radically sustainable education technology. *Learning, Media and Technology*. https://doi.org/10.1080/17439884.2022.2159978.

Selwyn, N., & Jandrić, P. (2020). Postdigital living in the age of Covid-19: Unsettling what we see as possible. *Postdigital Science and Education, 2*(3), 989–1005. https://doi.org/10.1007/s42438-020-00166-9.

Singh, R., Guzmán, R. L., & Davison, P. (Eds.). (2022). *Parables of AI in/from the majority world*. New York: Data & Society Research Institute. https://doi.org/10.2139/ssrn.4258527.

Star, S. L. (Ed.). (1995). *Ecologies of knowledge: Work and politics in science and technology*. Albany, NY: Suny Press.

Suchman, L. (2007). *Human-machine reconfigurations: Plans and situated actions*. 2nd Ed. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511808418.

Toombs, A., Devendorf, L., Shih, P., Kaziunas, E., Nemer, D., Mentis, H., & Forlano, L. (2018). Sociotechnical systems of care. In G. Fitzpatrick, K. Karahalios, A. Lampinen, & A. Monroy-Hernández (Eds.), *Companion of the 2018 ACM Conference on Computer Supported Cooperative Work and Social Computing* (pp. 479–485). New York: Association for Computing Machinery. https://doi.org/10.1145/3272973.3273010.

Tronto, J. C. (2020). *Moral boundaries: A political argument for an ethic of care*. New York: Routledge. https://doi.org/10.4324/9781003070672.

Tsing, A., Swanson, H., Gan, E., & Bubandt, N. (Eds.). (2017). *Arts of living on a damaged planet*. Minneapolis, MN: University of Minnesota Press.

Tunstall, D. (2017). Respectful design. https://www2.ocadu.ca/feature/dean-dori-tunstall-on-respectful-design. Accessed 20 December 2022.

Vetter, A. (2018). The matrix of convivial technology – Assessing technologies for degrowth. *Journal of Cleaner Production, 197,* 1778–1786. https://doi.org/10.1016/j.jclepro.2017.02.195.

Von Stackelberg, P., & McDowell, A. (2015). What in the world? Storyworlds, science fiction, and futures studies. *Journal of Future Studies, 20*(2). https://doi.org/10.6531/JFS.2015.20(2).A25.

Watters, A. (2020). Behaviorism won. Hack Education, 8 October. https://hackeducation.com/2020/10/08/behaviorism. Accessed 20 December 2022.

Williamson, B. (2019). Brain data: Scanning, scraping and sculpting the plastic learning brain through neurotechnology. *Postdigital Science and Education, 1*(1), 65–86. https://doi.org/10.1007/s42438-018-0008-5.

Williamson, B. (2022). Post-EdTech futures. NORRAG, 28 September. https://www.norrag.org/post-EdTech-futures. Accessed 20 December 2022.

Willis, A.-M. (2006). Ontological designing. *Design Philosophy Papers, 4*(2), 69–92. https://doi.org/10.2752/144871306x13966268131514.

Winograd, T., & Flores, F. (1986). *Understanding computers and cognition*. New York: Ablex.
Zakharova, I., & Jarke, J. (2022). Educational technologies as matters of care. *Learning, Media and Technology*, *47*(1), 95–108. https://doi.org/10.1080/17439884.2021.2018605.