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The Postdigital Turn: Philosophy, Education, Research
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Abstract
This article develops a post-determinist and a post-instrumentalist understanding of education and educational research through the lens of postdigital theory. We begin with historicizing current postdigital research by showing its intellectual ancestry and recognizing its rapidly changing nature. We move on to current state of the art, which we present in three wide themes. The first theme is the great convergence of various lower-level techno-scientific convergences, such as analog-digital, physics-biology, biology-information, which results in new epistemologies, ontologies, and practices. The second theme are some consequences of the great convergence for education and pedagogy, which result in new postdigital ecopedagogies. The third theme is postdigital research, which is reconfigured by the great convergence towards a closer collaboration between traditional scientific fields and disciplines. We briefly outline four such reconfigurations (multidisciplinary, interdisciplinarity, transdisciplinarity, and antidisciplinarity) and their implications. The article concludes with a brief list of directions for future work in the field.

Keywords: technological determinism, instrumentalism, postdigital, philosophy, epistemology, ontology, pedagogy, ecopedagogy, multidisciplinarity, interdisciplinarity, transdisciplinarity, postdisciplinarity

Introduction
In ancient times, people shared information through storytelling. The invention of reading and writing, and the rapid spread of written word after the advent of the printing press, had allowed people to communicate over time and space. Radio and television had reintroduced storytelling, turning communication and education at a distance into a mix between writing, speaking, and imagery. The last technological development, the Internet, has coalesced all forms of communication into a messy and rapidly changing mash-up, again reconfiguring relationships between text, sound, (still and moving) images, and other forms of communication[1]. Human culture "is about people teaching each other how to do things" (Rheingold in Jandrić 2017: 218), and education has always closely followed developments in communication. Therefore, it is hardly surprising that past decades' rapid developments in information science have significantly transformed teaching and learning. However, the relationship between technology and education reaches much deeper than communication. Since the second half of the 20th century, educational theory and practice has revealed complex reconfigurations in diverse fields such as philosophy, sociology, psychology, and others.

At the beginning of the Covid-19 pandemic, educational technology entered the spotlight. As worldwide governments temporarily locked down most teachers and learners in their homes,

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[1] This description is based on Marshall McLuhan's (1977) tetrad of media effects (see also Levinson in Jandrić 2017: 275).

online teaching and learning went mainstream. The sudden switch to "emergency remote learning" (Hodges et al. 2020) and the rise of "emergency EdTech" (Williamson 2020) introduced some new challenges; perhaps more importantly, it has revealed many tensions that have always been there (Rapanta et al. 2020). For some, the opportunity for a 'great online learning experiment' (Zimmerman 2020) seemed too good to miss. One year into the pandemic, occasional pandemic lockdowns, as existing and new variants 'spike' amongst specific populations, are part and parcel of the new normal. Based on pre-pandemic theories and recent experiences, most educational institutions have now prepared lockdown protocols that can be activated in times of need (Zhu and Liu 2020). After the first shock of the pandemic outbreak, it is time to explore its implications on educational theory, practice, and policy.

Within few short months, the world learned that teaching and learning, together with many jobs across all sectors of employment, can be done from home, and that traditional obstacles to digitization, such as the perceived inability to monitor workload, can be resolved successfully. One year into the pandemic, many employers have already figured out that it is cheaper to keep workers in their homes, thus opening up new ways for trimming down their fixed costs. In return, these cost reductions open up new frontiers for workers' emancipation (Bonilla-Molina 2020). Traditional inequalities, such as those following ancient colonial divisions between the Global South and the Global North, have also been reshaped by varying success of anti-pandemic measures (Mañero 2020). However, while it has been acknowledged that the Global South (Czerniewicz et al. 2020) had been under-equipped for the sudden switch online, both in skills and infrastructure, it was somewhat surprising to learn that parts of the Global North, such as Germany, suffered from similar problems (Kerres 2020). Other topics such as online workers' health, the general well-being of online teachers and learners, social justice and mobility, and others, have also experienced significant transformations, and post-Covid research in studies of education looms high.

The pandemic has caused some unexpected twists and reconfigurations, yet none of these questions are completely new. Already before the pandemic, Selwyn and colleagues wrote:

> As major shifts unfold, education the world over faces considerable change, but many of the problems that have long blighted education systems stubbornly persist. Schools around the world continue to face deficiencies in resourcing, significant inequalities of educational opportunity, alongside poor-quality teaching, curriculum and school organisation. These are all issues that pre-date the first 'computers in the classroom' and the subsequent forays into 'digital education'. (Selwyn et al. 2020: 1)

For decades, fields such as (critical) posthumanism, critical philosophy of technology, sociology of education, and many others, have pointed out that (educational) technology is profoundly and dialectically intertwined with the totality of the human (individual and collective) condition. In other words, technology is and always has been thoroughly *political*, rather than somehow existing outside of the assumptions and worldviews of their human designers and users. However, mainstream educational politics, policy, and practice, have stubbornly remained within the simplified discourse of 'instrumentalism' probably best described by the phrase "using technology to enhance learning" (Hayes 2019). As the Covid-19 pandemic has made us painfully aware of

inseparability of biology, information, and society, mainstream approaches are in a dire need for an update. According to Jandrić (2021: 262), post-Covid education should reach "beyond the pandemic to the point where the pandemic experience is transformed from an object of research to an intrinsic part of our theories, approaches, research methodologies, and social struggles". In this article, we seek a post-determinist and a post-instrumentalist understanding of education and educational research through the lens of postdigital theory.

Technological Determinism and Instrumentalism

Before seeking new understandings, it is useful to briefly examine the current state of the art. There is no doubt that decades of research and development in educational technology has produced some important historical achievements. However, against decades of critical research, simplified views to the relationships between education and technology have stubbornly persisted in mainstream educational policy, politics, and practice. In a world run by capitalism and competition, such uncomplicated renditions of technology have proved conducive to the desire for efficiency and performance. Situated within the neoliberal marketplace, policymakers, managers, and technology developers have focused on solutions which can be easily implemented, measured, and evaluated. This approach makes a lot of sense in policy papers, reports, and company budgets, yet its consequences are heavily contested (Hayes 2021a)[2]. With all its bells and whistles, the 'old normal' of teaching and learning had been anything but egalitarian, just, and sustainable. While this article cannot provide an in-depth overview of all wrongs in the 'old normal', two philosophical assumptions stand out as both factually wrong and negatively consequential.

One such assumption is technological determinism, which is a belief that technology somehow determines human societies and their values, structures, and so on. In this view, technological development is an intrinsically positive social force that education needs to adapt to. Technological determinism is also linked to a magical belief that using technologies will straightforwardly improve learning, purely by virtue of being present in educational activity. While there is a plethora of good research in the field, Sarah Hayes' *The Labour of Words in Higher Education: Is it Time to Reoccupy Policy?* (2019: xii) provides especially compelling evidence of the ways that words, in and around HE policy documents, shape "[t]he practice in HE policy discourse of displacing humans from their own labour, and instead attributing these processes to a range of non-human entities". Critical scholars have been revealing these fallacies and their consequences for decades. For example, through an analysis of the epistemological dimensions of the field of education technology, Czerniewicz (2010) exposes the lack of theoretical coherence. Oliver similarly finds "a poorly conceptualized field" (2015: 36) that, somewhat ironically, rarely engages with questions about technology itself, despite often being concerned with its advocacy. Yet, technological determinism still dominates today's educational policy, politics, and practice.

Closely related to technological determinism, is instrumentalism – a view that technologies are neutral tools which can simply be deployed to realise the intentions of designers or users. Students and teachers are locked down at their homes? Let's solve the problem by bringing them into a videoconference. Students and teachers cannot access the library? Let's bring electronic

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[2] This topic has been the focus of the Special Issue of *Postdigital Science and Education, 3*(1), entitled ' 'Measuring Excellence' in Higher Education'. See https://link.springer.com/journal/42438/volumes-and-issues/3-1. Accessed 22 April 2021.

books into their homes. Such neat solutions may look great in theory; indeed, who would object to a meeting from their home office, or getting their literature effortlessly delivered to their home device? Yet, an instrumentalist view problematically assumes that technology simply provides a solution, often with the assumption that we can carry on just as before. This significantly overlooks the ways technologies, rather than directly determining outcomes, exert their own influence. In this sense, rather than simply solving the 'problem' of distance, videoconferencing and electronic texts shape and change the ways we communicate, learn, and experience educational activity, rather than simply replicating existing lectures or libraries. Of course, neither do these technologies entirely determine the experience, which still resonates with many of the social cues of face-to-face interaction (in the case of video conferencing), or the very 'human' undertaking of reading and learning (in the case of accessing digital texts).

The point here is that the tendency to assume that technology is merely an instrument of pedagogical desire, drastically simplifies the ways we can understand the relationships between teachers, students, and technologies in education, and leads to an impoverished perception of how technology and educational practice are often thoroughly intertwined. Only by acknowledging such co-constitutive relationships with technology, as opposed to assuming that our 'tools' simply function as intended in a standardised pre-determined way, can we begin to ask more critical questions. For example, how is educational space being (re)produced and (re)configured in the 'video lecture'? Further, what happens to those who do not have Internet access at home; who work from their beds and kitchens; who are not technologically savvy enough to benefit from what is provided? Education technologies are not simply tools that enhance, or not, our educational activities, but are rather part of the complex human and non-human relations that co-constitute teaching and learning, in ways that resist and defy both the purposes built-in to the technical design, as well as any 'aims and objectives' that we might have as teachers or learners. Heidegger's concerns about neutrality are worth emphasising here: "Everywhere we remain unfree and chained to technology, whether we passionately affirm or deny it. But we are delivered over to it in the worst possible way when we regard it as something neutral." (Heidegger 2004: 3)

Critical educators have drawn on such work to point out various problems with instrumentalism for decades. As Hamilton and Friesen (2013) astutely observe, such perspectives actively limit research to examining whether technology 'works', or not, overlooking a vastly more productive and insightful range of questions about how technologies shape our lives, within education or otherwise. Oliver puts this succinctly, as a field "remaining caught up in for/against assertions about something we do not fully understand" (2016: 36). However, as can be seen from a recent account of 81 teachers' and learner's testimonies of teaching under pandemic lockdowns (Jandrić et al. 2020), rather simplistic understandings of education technologies as 'instruments' of intervention and enhancement still loom large in the field of educational research.

Philosophically, technological determinism and instrumentalism have been rejected at least since the mid-20th century and the work of the Frankfurt School of Social Science (Marcuse 1964; Heidegger 1981; 2004), and their persistence in educational policy, politics, and practice can be largely attributed to political economy. However, as it has become obvious that "[w]e are increasingly no longer in a world where digital technology and media is separate, virtual, 'other' to a 'natural' human and social life" (Jandrić et al. 2018: 893), technological determinism and instrumentalism have become unsuitable even in the simplest of applications. If technology is not

'the other', then it can neither single-handedly determine human relations and societies, nor it can be simply instrumentalized towards this or that goal. However, education is a huge, living system which requires a fully developed philosophy of praxis, and dismissal of technological determinism, instrumentalism, and associated theories means very little without development of an alternative philosophy of praxis. At the brink of the 21st century, a small but rapidly growing number of researchers have embarked en route to developing such theory under the banner of 'the postdigital'.

Welcome to The Age of The Postdigital
What is Postdigital?
In 1998, Nicholas Negroponte wrote a famous *Wired* article, 'Beyond Digital', in which he claimed: 'Face it—the digital revolution is over. … Like air and drinking water, being digital will be noticed only by its absence, not its presence." (Negroponte 1998) Soon after, Kim Cascone published his article 'The Aesthetics of Failure: "post-digital" tendencies in contemporary computer music' (Cascone 2000), and Pepperell and Punt published their book, *The Postdigital Membrane: Imagination, Technology and Desire* (2000). Published within the span of few months, without knowing about each other (Cascone and Jandrić 2021: 576), these first publications have given rise to development of the (then new) concept of the postdigital, which firmly rejected differences between the digital and the analog and sought a more nuanced understanding of their relationships. Cascone, for instance, located human presence in technological workings of the computer in computer glitches, thus significantly contributing to the tradition of glitch art (see Betancourt 2017).

In the first decade of 21st century, the concept of the postdigital has slowly expanded from music and visual arts into related fields such as architecture (Spiller 2009) and design (Berry and Dieter 2015). Soon after, the concept started to appear in the humanities (Hall 2013), social sciences (Taffel), and education (Cormier et al. 2019). Using various approaches, these works debated "[a] critical postdigital perspective, in which the digital can be seen as part (and, crucially, not apart) of the fabric of everyday life, [and which] can protect against rigid views of the qualities and effects of technology" (Cormier et al. 2019: 503). Finally, with articles such as Florian Cramer's 'What is Post-digital' (2015), and the inception of *Postdigital Science and Education* journal and book series[3], the concept of the postdigital has joined mainstream research in the humanities and social sciences.

In the mission statement article for the journal and the book series, there is an oft-cited definition that says: "The postdigital is hard to define; messy; unpredictable; digital and analog; technological and non-technological; biological and informational. The postdigital is both a rupture in our existing theories and their continuation." (Jandrić et al. 2018: 895). Since 2018, this definition has been critiqued and expanded in numerous directions. Reflecting on the term 'post' and its responsibility for entrenched assumptions about the digital, Knox (2019b) suggests three avenues for developing educational research that directly examines the increasingly entangled relationships between education and technology: the growth of private investment in, and development of, educational technologies in ways that expose public education to capitalist

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[3] Postdigital Science and Education journal, https://www.springer.com/journal/42438. Book series: https://www.springer.com/series/16439. Accessed 22 April 2021.

exploitation (a tendency which has intensified dramatically during the pandemic); the ways data-driven technologies shape high-level educational governance and policy; and the building up of the material infrastructures and devices necessary to sustain networked and 'cloud-based' activity, often with significant environmental and human labour consequences. These examples demonstrate the ways in which it is becoming ever more untenable to maintain the discourses of 'flexibility', 'empowerment', 'innovation' and 'virtuality' that portray the digital as existing in a kind of pristine domain, outside of the fallible analogue world of humans, and able to miraculously solve their problems.

In this sense, Knox (2019b) suggests the postdigital to be a call for educational research that acknowledges the messy, entangled, and unpredictable nature of the socio-technical relationships that constitute education, rather than relying on the tired interest in "technological enhancement" that has dominated the field for decades. This also entails a more expansive view of "what counts" as educational research, in a field dominated by insular concerns for classroom practices, teacher identities, and measurable learning outcomes. For Knox (2019b), such perspectives need to be expanded (and thus transformed) by wider acknowledgement of the co-constitutive social, political, economic, and environmental facets of our digital education endeavours.

With some exceptions, such as Sinclair and Hayes' (2019) work on complex entanglements between biological and digital modes of existence, Peter McLaren's (2019: 11) work on the "kind of socio-historical human agent do we wish to nurture in a postdigital society", Ben Williamson's (2019) work on the research of brain data, and Maggi Savin-Baden's (2021) work in postdigital humans, postdigital research in the period 2018-2020 has predominantly focused to the digital-analogue side of the definition. Yet in 2020, the Covid-19 pandemic has radically disrupted postdigital research. As the Postdigital Science and Education community quickly responded to the pandemic, resulting in many dedicated articles recognized and used by organizations such as the World Health Organization, the US National Library of Medicine's Nature Public Health Emergency Collection, and UNESCO (see Jandrić 2021 for details), postdigital theory has started to refocus.

Worldwide governments rapidly introduced various informational mechanisms for tracking the infected, and worldwide researchers started to openly share their Covid-related research (see Peters, Jandrić, and McLaren 2020). As the pandemic has made us painfully aware of the fragility of our biological existence, the focus on digital-analog aspects of the postdigital has been quickly replaced with a focus on the continuum of biology-information. This is typical postdigital "rupture and continuation" (Jandrić et al. 2018), as "pre-pandemic postdigital theory offers many 'hooks' into which such research could get a hold" (2021: 262). However, theoretical hooks are miles from developed theories. "[T]he ruptures produced [by the postdigital] are neither absolute nor synchronous, but instead operate as asynchronous processes, occurring at different speeds and over different periods and are culturally diverse in each affected context" (Cox 2014). Therefore, it is important to historicize current postdigital research by showing its intellectual ancestry and recognizing its rapidly changing nature. This rest of this article presents this latest phase in postdigital research, which has started with the advent of the Covid-19 pandemic, and which is now in full swing.

The Great Convergence

Since the beginning of the 21st century, we are witnessing a rapidly growing body of research on various techno-scientific convergences. Describing "the coming biology revolution", the U.S. National Research Council (2019) claims that new biology approaches "depend on greater integration within biology, and closer collaboration with physical, computational, and earth scientists, mathematicians and engineers". Bainbridge and Roco (2006, 2016), Peters (2020a, b), and others, extensively speak of the 'Nano-Bio-Info-Cogno Paradigm' which implies unity between biology, information, and cognitive sciences at a nanoscale. Behind all this are what Susan Hockfield (2019) conveniently defines as Convergence 1.0 (the convergence between physics and engineering) and Convergence 2.0 (the convergence between biology and engineering); in philosophical literature, these convergences pre-date the great convergence under the common name of technoscience (e.g. Stiegler 1998, 2007; Latour 1987)[4]. Recently, Peters, Jandrić and Hayes (2021a) have started to connect the dots between described convergences, biodigital philosophy, and New Knowledge Ecologies. Importantly, the convergences are mutually inter-related – for instance, the convergence between biology and information is enabled only through a convergence of science and technology. In a follow-up article, Peters et al. wrote:

> This signals that our neatly divided convergences (biology+information, science+technology, etc.) require a meta-convergence. We, thus, arrive to the postdigital convergence of information, biology, science, technology, politics, society and various other phenomena that remain unmentioned. In its original formulation, this postdigital convergence has arrived from our descriptions of the postdigital condition (see Jandrić et al., 2018), but it equally speaks to 'lower-level' convergences such as science+technology. (Peters, Jandrić, and Hayes 2021b)

This classification to high-level postdigital convergence and lower-level convergences between scientific fields and disciplines is useful, because it links postdigital theory and practice. Our research often requires a certain focus (for instance, curriculum), and we need to somehow balance that focus with general ideas and principles (for instance, approaches to using learning technology). According to Peters et al. (2021b), "[w]hile it is completely legitimate (and often necessary) to focus one's work to lower-level convergences and their consequences, we need to remember that lower-level convergences cannot be fully understood without the higher-level postdigital convergence".

The great convergence is mutually constitutive with political economy (Knox 2019, 2020). Researchers in various fields have explored recent reconfigurations of capitalism and have given them different names. According to Jandrić and Ford (2020), some of the most relevant theories of new capitalisms for education include data capitalism (Fuchs 2019), algorithmic capitalism (Peters and Jandrić 2018: 32), communicative capitalism (Dean 2009; Ford 2018), surveillance

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[4] More about these convergences and their applications to various fields can be found in Peters, Jandrić and Hayes (2021a, b). The convergences are also a topic of a book edited by Peters, Jandrić, and Hayes, *Bioinformational Philosophy and Postdigital Knowledge Ecologies*, forthcoming in Postdigital Science and Education book series.

capitalism (Zuboff 2019), technoscientific capitalism (Birch and Muniesa 2020), and high-tech and low-pay capitalism (Marcy 2009). Already in 2012, Michael Peters defined bioinformational capitalism:

> Bio-informational capitalism is the emergent form of fourth or fifth generational capitalism based on investments and returns in these new bio-industries: after mercantile, industrial, and knowledge capitalisms. This is a form of capitalism based on a self-organizing and self-replicating code that harnesses both the results of the information and new biology revolutions and brings them together in a powerful alliance that enhances and strengthens or reinforces each other. (Peters 2012: 105)

Within the pandemic outbreak, there have been various attempts to develop these ideas further in concepts such as viral modernity, which "applies to viral technologies, codes and ecosystems in information, publishing, education and emerging knowledge (journal) systems" (Peters, Jandrić and McLaren 2020; Peters and Besley 2020). Philosophical research on the great convergence is at its very infancy, and it is hard to say which of these competing concepts will stand the test of history.

While we develop our philosophies, the great convergence already yields numerous practical implications. One prominent implication is the emergence of the bioeconomy as described in publications such as OECD's (2009) book *The Bioeconomy to 2030: designing a policy agenda* and fostered by national governments in countries such as China, India, and the UK (Salter et al. 2016). Another prominent implication is the inseparability of various crises such as the coronavirus crisis, the environmental crisis, and others (see Jandrić et al. 2020). "Our physical microbiological contact is an expression of our biological interconnectivity which also has cultural, social and political dimensions that are played out through the means of a technological superstructure that takes many digital and postdigital forms." (Peters et al. 2020) The great convergence is thus an epistemology, an ontology, and a crucial aspect of our everyday life. In the next section, we will explore some consequences of the great convergence for education and pedagogy.

Postdigital Ecopedagogies
For decades, studies of education have extensively researched the lower-level convergence between the analog and the digital under various names such as e-learning, networked learning, technology enhanced learning, and others. Another important lower-level convergence, emerging from the dialectic between biology and information, can be found in various posthumanist approaches to education. Yet another important lower-level convergence, between education and the environment is long established, with recent examples being work on sustainability (see Higgins and Christie 2020). With some exceptions, such as the University of Edinburgh's Centre for Research in Digital Education (see Bayne et al. 2020)[5], these convergences have been approached predominantly in isolation. Educational technologists rarely care about environmental impacts, posthumanists rarely engage in policy-level curriculum development, and so on.

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[5] See https://www.de.ed.ac.uk/. Accessed 22 April 2021.

In our postdigital condition, however, these siloed approaches require urgent replacement by a higher-order convergence between the analog and the digital, biology and information, education and the environment. With respect to this latter convergence, Selwyn (2018) provides an overview of the environmental consequences of 'EdTech', suggesting 'every use of digital technology contributes to the degradation of our planet in ways that education urgently needs to face up to' (Selwyn 2018). Outlining 'end-to-end' environmental consequences, from the mining of the rare-earth minerals required to make handheld devices function, to the energy required to run data-driven software, to the ecological cost of disposing of unused and outdated technologies, Selwyn (2018) demonstrates the tangible dangers, not only for the planet but also for the living conditions of future human life, of remaining in disciplinary isolation.

In their recent research project, Jandrić and Ford (2020) embark on this task from the ecopedagogy movement[6]. Officially founded at the second Earth Summit held in Rio de Janeiro in 1992, the ecopedagogy movement has developed a reasonably-sized body of theory oriented to development of curricula and pedagogical practices about environmental issues. Working towards the great convergence, Jandrić and Ford (2020) identify potential lineages, directions, and lines of educational praxis which could contribute to development of postdigital ecopedagogies: Critical Philosophy of Technology and Studies of Science and Technology (STS); Big Data, Algorithms, Artificial Intelligences, and New Capitalisms; Bioinformational Capitalism and Viral Modernity; Anti-imperialist, Anti-colonial, and Decolonization Studies/Movements; Postdigital Feminisms; Intersectionality and Identity Politics as Ecologies of Collective Resistance; (Critical) Posthumanism and Transhumanism; Critical Disability Studies; Queer Theories; Postdigital Aesthetics; (Science) Fiction and Future Studies; and Myth, Religion, and Belief. Jandrić and Ford conclude:

> Ecopedagogies have to, then, consider the nexuses identified above (and more!), while disavowing fantasies of political, bodily, and digital immunity and embracing the opacity, contingency, uncertainty, and interdependent vulnerability of all things to transform the animacy hierarchy into a horizontal configuration of human/nonhuman/object. We need to invent new postdigital ecopedagogies that are critical and creative, certain and indeterminate, transparent and opaque, and that accept and negotiate the contamination of the constantly shifting borders between humans, machines, nature, nonhuman animals, and objects. (Jandrić and Ford 2020)

This accent to criticality, creativity, and justice through a convergence of this long and diverse list of disciplinary fields and intellectual traditions sounds like a teenager's birthday wish list. Philosophy of the great convergence is in its infancy, so it is far from clear how insights developed in incommensurable epistemic frameworks can be brought together, and what such integration would imply. Practical implications are also unclear, as balancing such a diverse body of insights is policy-makers' worst nightmare. Furthermore, theory and practice cannot just mix and match, and "we cannot be sure which of the listed (and indeed non-listed) perspectives and/or

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[6] Jandrić and Ford's article is the basis for an edited book, *Postdigital Ecopedagogies: Genealogies, Contradictions, and Possible Futures*, forthcoming in Postdigital Science and Education book series.

combinations thereof will be more relevant than the next one." (Jandrić and Ford 2020) Today's postdigital ecopedagogies are in the phase of 'primitive accumulation' of knowledge, and that calls for active research and fearless experimentation.

Such a concern for postdigital ecopedagogies might be linked to emerging broader theorisations of technology, such as "cosmotechnics", a rethinking of Heidegger's analysis of the essence of technology in light of decolonial studies and the ontological turn (Hui 2016, 2020). As such, "cosmotechnics provides us with a conceptual tool with which to overcome the conventional opposition between technics and nature, and to understand the task of philosophy as that of seeking and affirming an organic unity of the two" (Hui 2016: 20). This is derived specifically from a move to diversify technology from the universalist "monotechnologism" (Hui 2020) that current dominates our understanding, towards recognition of the idea that "technologies in different cultures are affected by the cosmological understandings of these cultures." (Hui 2016: 19)

Hui, in *The Question Concerning Technology in China* (2016), explores alternatives to the dominant euro-centric and universalist views of the history of technology (also as the history of nature) by drawing on ancient Chinese thought. Drawing on the Daoist concepts of the *Qi* and *Dao*, as well as considering such movements as Neo-Confucianism, cosmotechnics proposes to move beyond the "empty rationality and calculation" underpinning Western views of technology (Hui 2016: 288) towards "reinventing the self and technology at the same time, giving priority to the moral and ethical" (Hui 2016: 290). Hui further suggests that such a "diversification of technologies", of which the discussion of Chinese perspectives would be one such example, "also implies a diversification of ways of life, forms of coexistence, economies, and so forth, since technology, insofar as it is cosmotechnics, embeds different relations with nonhumans and the larger cosmos" (2020). In this sense, reassessing our understanding of technology becomes vital to the sustainability of life itself:

> The mono-technologism we live now ignores the necessity of coexistence and continues to see the earth merely as a standing reserve. With the vicious competition it sustains, it will only continue to produce more catastrophes. According to this view, after the exhaustion and devastation of spaceship earth, we may only embark on the same exhaustion and devastation on spaceship Mars. (Hui 2020)

At our current moment in history, techno-determinist and instrumentalist pedagogies are not anymore (although it remains easy to slip into their assumptions), and postdigital ecopedagogies are not yet. This inter-regnum position is a foe, because it is very hard to offer practical advice, and a friend, because it offers an opportunity to reimagine our present and future. This reimagination is about warning against negative developments, such as the growing authority of data-driven forms of behaviouristic pedagogy in formal and informal education, or 'machine behaviourism' (Knox et al. 2020), and about designing a better future. In these conditions, a recent surge in social science fiction is hardly surprising (see Costello et al. 2020; Selwyn et al. 2020). One pertinent example here is the range of profound political and societal shifts engendered by increasing datafication, for which scholars are turning to fiction as a way of articulating the often-complex, ambiguous, and unpredictable condition of 'living with data' (see Kitchin 2021). Kitchin suggests of fictional writing:

Storytelling has always been a powerful way of communicating ideas and providing a critical lens to consider society and social processes and change. Short stories, novels, comics, documentaries, biographies, television dramas and movies provide media that can be more provocative and playful than academic accounts. They can set out different views and explore values, conflict and consequences using various forms of narrative devices. (Kitchin 2021: 7-8)

Significantly, such approaches to writing may offer tangible ways to develop creative and alternative futures to the more dystopic scenarios often suggested through more formal empirical research. Indeed, Kitchin proclaims that "while the data revolution seems to have a relatively robust path dependency, it can be diverted onto new routes. We can create our own data lives." (2021: 7) Fictional research methods are highly relevant to an education sector that is increasingly subject to intensive datafication, as explored in a recent project "speculative data stories", developed to "to understand and *shape* data futures and surveillance practices in universities" (Ross 2021 emphasis added). Alongside such speculative methods, critical pedagogy, and its long tradition of utopian thinking, offers important directions for a forward-looking reimagination of education. "Situated between being and becoming but without disparaging the past or adhering to linear models of development or time, utopian pedagogies have an urgent and important role in intervening in our (post)-pandemic reality." (Jandrić and Ford 2020) The first steps in this direction are conscientization and internalization of postdigital complexities (Freire 1972) and rejection of reductionist philosophical positions such as technological determinism and instrumentalism.

Postdigital Research
The great convergence implies collaboration between traditional scientific fields and disciplines. Focused on reconfigurations of relationships between the analog and the digital, early postdigital research has already done some steps into that direction (Knox 2019; Jandrić 2020). Traditionally, this collaboration can be found under following names:

- Multidisciplinary, which implies studying one research question simultaneously in different disciplines. For instance, online education can be independently studied in pedagogy, computer science, and sociology. Such approaches often remain resolutely within their own disciplinary practices and cultures, with little formal or procedural opportunities to expose research to different perspectives.
- Interdisciplinarity, which implies studying one research question within an integrated system made of various disciplines. For instance, policymakers may blend multidisciplinary insights into online education into a coherent piece of research which will include pedagogy, learners' Internet connectivity, and their social status. While interdisciplinarity appears *de rigueur* in the discourse around contemporary research, the extent to which methodological approaches tend to remain fixed within specific disciplinary customs has been noted as a concern (at least by proponents of transdisciplinarity, see below). The so-called 'data revolution' in academic research is a pertinent example here, where the techniques of 'machine learning' and other data-

intensive approaches are often framed as providing the potential to transform other disciplines, for example through analysing unprecedented volumes of image data in the medical sciences, or by scanning extraordinary quantities of historical documents in the humanities, and of course through crunching ever-increasing sets of 'learning analytics' data in education. While such interdisciplinary ways of working may produce novel outcomes, the extent to which such 'data science' methods end up tightly defining, and restricting, the forms of knowledge that can result, is a subject of growing concern. Interdisciplinarity, thus defined, therefore doesn't appear to pay enough attention to the ways particular, *en vogue* methods can become dominant or overly authoritative.

- Transdisciplinarity, which implies a gathering of various research approaches around a common problem, which transforms 'original' research methodologies arriving from each discipline. For instance, sociological research of online learning in a certain population may transform pedagogical research, depending on characteristics of that particular population, in various directions from computer literacy to multiculturalism. In this sense, transdisciplinarity suggests a better route to methodological plurality than interdisciplinarity, which as suggested above, can tend towards a single set of methods and disciplinary assumptions being "applied" across a range of disciplines.

- Antidisciplinarity, which implies a sort of Feyerabend's (1993) 'epistemic anarchy; a research space where every combination of research methodologies can potentially work, for as long as it can be justified by the problem. For instance, online learning can be inquired using several incommensurable methods such as psychology and arts-based methodology, which may or may not transform each other, and which may or may not epistemically fit together. (see Jandrić 2016 for an extensive overview of these approaches).

In various fields of today's research, it has become necessary, acceptable, and often even fashionable, to mix and match research methodologies. Common practices in educational research include various combinations of qualitative and quantitative methods. There is also a wide array of 'critical' approaches, some of which have very little to do with critical theory proper. This messy state of the art requires a lot of conceptual clarification and differentiation of postdigital epistemologies and research practices – which is an urgent task for today's postdigital scholarship.

Conclusion

As we write these words, postdigital approaches are under rapid development, and it is impossible to offer an authoritative or even systematic overview of postdigital theory and practice. Things are not made easier by the extreme widening of the discourse brought about by the great convergence. Despite these restrictions, it is useful to try and wrap up recent research efforts into a more coherent narrative.

Postdigital philosophy is open to different approaches, theories, and ideas. Probably most importantly, postdigital philosophy cannot be thought of without practice; in the tradition of Freirean (1972) critical pedagogy, this results in a postdigital philosophy of educational praxis. In our age of rapid environmental degradation and the Covid-19 pandemic, all postdigital pedagogies are necessarily ecopedagogies. This does not imply simple addition of ecological concerns to our existing pedagogies, but a transformation of existing pedagogies towards an in-depth recognition

of the dialectic between biology and information. In educational research this implies higher levels of disciplinary integration, such as transdisciplinarity, where incommensurable traditional methodologies meet at a higher conceptual plane and transform each other.

These grand claims work well in theory, but what about practice? Following Freire's (1972) theory of conscientization, the first step towards developing postdigital research is to recognize shortcomings of technological determinism, instrumentalism, neoliberal framings of education, and other perils haunting educational theory and practice. This rejection is followed by development of alternative narratives, and alternative philosophies of praxis, that may push our theories and practices into a postdigital direction. As we develop educational politics, policy, theory, and practice in the environment focused on the analog-digital aspect of the postdigital condition, "the Covid-19 pandemic has given us a strong reminder of the recent bioinformational and technoscientific convergences and an important message that postdigital really useful knowledge lies at the intersections between biology, information, and society" (Jandrić 2021: 264). As we develop the new normal, an awareness of these and other postdigital convergences need to be built deeply into our theory and practice of tomorrow's education.

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