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Sensing bodies: transdisciplinary enactments of ‘thing-power’ and ‘making-with’ for educational future-making

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SENSING BODIES: TRANSDISCIPLINARY ENACTMENTS OF ‘THING-POWER’ AND ‘MAKING-WITH’ FOR EDUCATIONAL FUTURE-MAKING

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Abstract: Dominant conceptions of education are strongly framed by narratives of ‘power-over’ materials, context, and processes, especially where digital and technological applications reduce complexities between humans, materials, and environments. The separation of knowledge, tools, and bodies in ‘disciplinary bounded’, ‘copyrighted’, and ‘patented’ spaces create a disconnect from our need for sustainable relationships, whereby the future is not given but ‘in-the-making’ (Haraway 2016). Drawing on music and science – as examples of distinct disciplines, often siloed and separated in education – this paper advances nuanced understandings of how post human conceptions of ‘thing-power’¹ (the power of all bodies including materials) and ‘making-with’ (whereby everything makes each other capable) contribute to the affective encounters of materialities within the classroom. By foregrounding the *sensing body* as a means to touch and be ‘touched’ by the world, we uniquely contribute to methodologies that illuminate the relational intensity of material sensation as part of coming to ‘know’. In doing so, we engage with the performative work of these materialities and re-define the ‘digital’ beyond the delivery of pre-planned learning pathways.

Keywords: *transdisciplinarity; vital materialities; thing-power; making-with; relationality; bodies; touch; sensing; temporal diffractive analysis*

Introduction

Educational systems increasingly feature digital and technological apparatus to widen and expand the delivery of knowledge and curricula. Within what Williamson and Komljenovic (2022) describe as ‘techno scientific capitalism’, large investments from Edtech companies are moving away from the exchange of goods and commodities to focus instead on producing models of teaching and learning that can be standardized and commercialized for durable economic returns in the future (Decuyper et al., 2021). Arguably, this has deeply transformative impacts on how education *could*

¹The hyphenation of words - such as with ‘power-over’, ‘making-with’ and ‘thing-power’ – is a posthumanist practice which invites new forms of engaging, reseeing, and thinking about the word.

or *should* be. Characteristically, technological interventions in education reinforce and promote narratives of knowledge acquisition as ‘power-over’ (Allen 1999) materials, contexts, and processes; they encourage individualization of effort and interactions, a separation of bodies (human and non-human) in ‘bounded’, copyright-protected and patented spaces (Castaneda and Selwin, 2018). The configuration of materials and technologies as merely tools for gaining competitive economic advantage (Moss, 2014) reinforces linear trajectories of learning towards pre-defined outcomes, which do little to exercise the power of thinking-with things and making-with others (Murriss and Bozalek 2022, p.160).

Such problems are compounded by a knowledge system that promotes disciplinary ways of working, with their embodied habits, defined relationships, and material-linguistic structures (Klein, 2015, Davies and Trowsdale, 2021). We see these disciplinary structures and hierarchies being the focus of knowledge-rich curricula, as in the case of England, Finland, or Australia (Szabo et al, 2021), whereby skills and understanding are sequenced and specified in detail within the realm of a subject-domain, and then measured on standardized assessments for comparative performance (e.g., PISA). We also see it in the ways specialist disciplinary teachers embody ‘what it means to be teacher’ in their habitual responses during teaching, abiding to established language and norms and finding dissonances when asked to ‘be differently’ (Cooke 2021, Davis et al. 2020).

Yet, the dappled and fragmented view of disciplines, dividing the world in discontinuous variables, is challenged by contemporary awareness of current complex issues, that are multi-levelled, involving a multiplicity of actors and impacts. In education, these questions have informed the case for curriculum reform (OECD 2020), and the ongoing proliferation of research around inter- and transdisciplinary practices (Russell et al. 2008, Klein 2015), challenging the separability of disciplines, and calling for new research and educational practices vis a vis global challenge.

Unique methodological contribution

Seeking to advance debates on digital discourses and knowledges, this paper draws upon posthumanist thinking to foreground the ‘sensing body’ as a prime locus and a threshold concept for rethinking the nature and purposes of educational inquiry. In doing so, this paper critically advances the potential of transdisciplinary practice, transgressing disciplinary habits and learnt responses, to create a relational space in which humans and more-than-humans (materials, environments, including and not exclusive to the digital) are inter-reliant *with* each other, neither being more important than the other, but entangled in practices of forging a way together, in what Karen Barad calls ‘worlding’ (Barad 2007, p.142).

Specifically, we advance a nuanced understanding of the posthuman concepts of ‘thing-power’ and ‘making-with’ as key methodological constructs for enacting transdisciplinary practices, within and across two examples of music and science education. As two disciplinary fields that are often siloed as specific areas of knowledge and professional practice, both domains uniquely enact entanglements with objects, bodies, instruments, time and spaces, doings, and actions, where the materiality and performative power of transdisciplinary actions radically re-configures the educational space and the realm of the possible.

And so, we ask, ‘what if’ and ‘how to’ questions concerning the contribution of posthumanism to fundamentally re-define the ‘digital’ beyond technology alone and the delivery of learning pathways already planned. It is, we argue, through making-with *sensing bodies*, whereby knowing is a process of ‘re-seeing’ ourselves with(in) the world that we can uniquely advance – as Barad (2012) suggests

- being open to the world's aliveness, literally *being in touch* with its bodied encounters of material and affective figurations and reconfigurations. Developing methodologies that illuminate relational intensity between / through / with bodies (human and non-human), this paper also contributes to greater understanding of how to use modulations in sensorial experiences to challenge linear / bounded disciplinary practices and views of knowing, developing methodological tools that illuminate and allow re-seeing the encounters of both material and affective materiality in contemporary educational contexts.

Conceptual Framing

This paper draws particular attention to three interrelated concepts - thing-power, making-with and sensing bodies - forming the outline of a posthumanist imaginary through which we progressively re-read our everyday encounters with educational discourse and experiences of our students, seeking new insights into the nature of a world in the making.

Thing-power and making-with

Thing-power according to Jane Bennett (2010) refers to the material co-constitution and 'vitality' of bodies, and the vital materialisms of nonhuman bodies. By 'vitality', Bennett means

"the capacity of things – edibles, commodities, storms, metals...to act as quasi agents or forces with trajectories, propensities, or tendencies of their own....to articulate a vibrant materiality that runs alongside and inside humans" (p.viii).

These things are a source of action that can be either human or nonhuman, whereby they can make demands, through their specific characters, to provoke us in multiple ways. On encountering things (whether a pile of sticks, wool, pencils, playdough or musical instruments that commands attention from us), thing-power matters and comes to matter. Yet such mattering is not the coming into contact of inert bodies left unchanged as they might have been described in the Universe of Newtonian mechanics. And mattering extends beyond traditional semiotics seeking to capture meaning in language. Rather, things come to matter as cultural formations, extending meanings through connecting between-across-with multiple senses (Massumi, 2002).

Hence Bennett's conceptual work on thing-power heralds a call to develop new ways of looking and responding, "that enable us to consult nonhumans more closely" (Bennett 2010, p.108). This, she suggests, involves "a cultivated, patient, sensory attentiveness to nonhuman forces" (p.xiv); an attuning to the thing-power of matter and matter's vibrancy.

It is this *attunement* which so closely involves the body. For Bennett, bodies are associative, social, and affective, they form alliances with other bodies, creating "living throbbing confederations" (2010, p.23) through their entanglements with each other. As with productive coalitions, they require all involved (human and otherwise) to be receptive, responsive, and open to what the other partner offer, as ways to move together in the ongoing material co-constitution of the world.

So, thing-power is not simply referring to knowledge. Instead, it invokes the recognition that nothing, no one body or thing, is made without a process of mutual togetherness in which we are attentive to how entanglements inform who we are, and how we become together. This mutuality of being and becoming is expressed by Haraway (2016) as making-with, a process that is contingent on allowing ourselves to see/feel/hear the thing-power of our material partners coming to being

through intra-active relationships. These *intra-actions*, which Barad (2007) defines as “the mutual constitution of entangled agencies” (p.33), where everything ‘becomes’ in relation to everything else through relational connectivity, are ‘imprinted’ on our practices, providing ‘traces’ of how entangled relationalities across time and space act as a force on the present (Murriss and Bozalek 2019).

Sensing bodies

Both science and music education make-with sounding, sensing bodies, where reverberations (audible, felt and observed) spread, make and disrupt through sensing intra-actions with materials and through the music of objects. And yet, as bounded disciplines with strict modes of being scientist / musician, these reverberations, these moments of making-with, are often bounded in both language and relationships. Similarly, some disciplinary practices within education downplay vital relationalities, where encounters with the materialities of disciplines, especially those with specialist material equipment and patterns of engagement - such as sciences and music - are considered subservient to human cognition, of either teachers or learners. Here the role of *the sensing body*, and *the materiality of the body*, particularly *touching encounters* through the hands and fingers, but also through the ears vibrating at the ‘touch’ of sound waves, are often undertheorized in relation to knowing. Specifically, conceptualising ‘touch’ as a way of knowing can be understood as a reversal mode of being touched and touching (Merleau-Ponty, 1968, p.138), where “the act of touching inverts the subject-object relationship, disrupting the boundaries between self and other” (Stewart 1999, p.31).

And yet, as illustrated by Parke and Plutinski (2020), biologists go about producing their theories and explanations, literally by building and manipulating their own, tangible, constructed models. Embodied thinking, or thinking through and with the hands, posits the body as the threshold of experience, of touch as a way of knowing and encountering self and other, is connected to linguistic and reflective capabilities. Hence neither the scientists nor the artists can be detached, unchanging observers, and instead their ‘artful empiricism’ (van Boeckel, 207, p.145) lies with their being participant, present to the lives of others as they unfold.

In this sense, both music and science are not reductively concerned with the pre-sensorial identification and reproduction of either physical or musical ‘objects’; but both scientific and musical knowing are made-with, in a state of attentive receptiveness to the intense vibrations of matter, which are at once internal and external to the body (both human and otherwise). Almost a century ago, speaking of the role of the body in aesthetic knowing, Dewey (1933) described: “sounds come from outside the body, but sound itself is near, intimate; it is an excitation of the organism; we feel the clash of vibrations throughout our whole body” (p.246), whereby the reverberations of our human-material, posthumanist realities, past-present realities are felt.

To make-with therefore requires us to be vulnerable and yet open to the possibilities that emerge from our intra-action with the thing-power of entanglements. As Rosi Braidotti argues, embracing this vulnerability is an “express[ion of] the deeply affective and relational nature of all living entities” (Braidotti 2019, p.169), which she goes on to contend is a “vital bond” for “generative power” (ibid.169). It is this generative power of making-with, as a way of making differently-new-beyond expected disciplinary modes, as transformative to self and each other, that Lenz Taguchi (2010) maintains is not equated to forcing change. Rather, it requires us to be minoritarian, “put[ting] ourselves in a state of becoming-other [where we deliberately pay attention to] change and changes in ourselves, but also in the [material]” (Lenz Taguchi 2010, p.172).

Therefore, to be minoritarian is *to attune to* and make-with the materiality, the particular thing-power and what it offers to our relationships. As we will further articulate in the paper, this is a vulnerable and creative space, where uncertainty about where such making-with takes us together, challenges educational practices of linear progress and pre-destined outcomes. *To attune to* is both a methodological and ethical stance, that invites what is possible, and therefore what we can make-with the materiality of our encounters. Explicitly acknowledging the sensing body in knowing - and the potential this has for making-with - opens the space for transdisciplinary practice as we explore through our empirical cases.

Transdisciplinarity enactments

Transdisciplinarity, as a “practice that transgresses and transcends disciplinary boundaries” (Russell et al. 2008, p.460-461), offers us the potential to “respond to new demands and imperatives”, by de-coupling specific disciplinary language and meanings, and allowing them to be opened to new possibilities of seeing and experiencing them from different perspectives. However, drawing on the earlier conceptions of sensing bodies, such decoupling or deterritorialising is not just about *the movement of language*, but also, and primarily, *a moving of bodies*, where language - including turns of phrase - are rooted in embodied practices (Burnard, Colucci-Gray and Cooke 2022). The movement and sensorial experiencing of the body is essential in transdisciplinary enactments, in developing different and *new forms of relationalities* (Bennet 2010). These new relationalities involve a re-touching, re-embodiment of existing language to *turn the tide* in the ways in which words have “become ‘numbed’ or seem to have ‘lost touch’ with life” (Bennett 2010, p.54). This is often reflected in educational practices where “curriculum materials...[often] assume children learn best ‘about’ [a subject] ...without being in touch (literally) with the real world” (Murriss and Muller 2018, p.156). Instead, Bennet (2010) argues, all things are in entangled “throbbing confederations” (p.23) that challenge dualistic distinctions and fixed categorisations. Such power of coming together, of seeing the world ‘through the skin’ troubles acquired notions of predictability, linearity, and intentionality, for there is an “infinite set of possibilities, or infinite sum of histories for a particle touching itself, and then that touching touching itself, and so on, ad infinitum.” (Barad, 2012, p.212).

Similarly, the image of *affective bodies* forming assemblages captures the process of *transdisciplinary enactments*: not as the mechanical addition of disciplinary notions or ideas in the head or in a mechanical device, but as the possibility of coming into contact, into collision even, across multiple sensorial planes; whereby the feeling and the sensing is at once a biological, physical, linguistic, and sonic experience. From this perspective, transdisciplinary enactments are akin to rhizomatic encounters (Deleuze and Guattari 1987), expanding horizontally in their *sensing and being sensitised to one’s own and other natures*: a ‘touching encounter’, a co-mingling in which “human and non-human matter composes” (Springgay 2018, p.59).

By deterritorialising (the harsh realities of) disciplinary bodily norms (i.e., learning/doing music limited to mastery of instruments; learning/doing science as manipulating lab equipment), we foreground the *role of the body as touch-ful experience*, that is a key constituent of both making-with and thing-power. We create spaces to re-make, re-think and re-connect embodied meanings with (and through) materials, practices, and ways of being-with to re-think the meaning of the digital across different realms of education, that are otherwise kept separate.

Posthumanist Methodological Horizons: Enactments in/across Two Cases

The two cases in this article foreground the *role of the sensing body*, and the experience of *touch assemblages* hereby afforded, as a site for ‘troubling’ disciplinary norms, habitual responses and assumptions about knowing. Re-seeing making-with and thing-power, as contingent on activating the sensing body, enabled us to explore the relational intensity of *material sensations* in each project, although the two cases are differently situated, and therefore the performative acts of making-with and thing-power are differently experienced.

One project involved a group of 8 Masters level science students taking the elective course *Methodologies for Teaching in the Life Sciences*, taught entirely online by the Visiting Professor based in the United Kingdom with the students based in Italy. This course runs alongside other disciplinary content-based science courses (e.g., palaeontology, zoology etc.) and it is normally elected by science specialists who have an interest in educational studies without being part of a professional qualification for teaching. Here we focus on a specific part of the course syllabus, where an initial activity on the distinction of living and non-living, that is a common topic in biology education, surfaced the limits of categorisation as dualistic separations; this was followed by a drawing activity, whereby with eyes closed, students experimented with touch and mark-making, sensing the responsiveness of materials and their intra-active relational intensities (Barad 2007) across multiple times and spaces.

The second case, a PhD project exploring music teaching as an improvisatory act, involved a group of 8 undergraduate and postgraduate music student teachers enrolled in a pre-service teacher degree. During transdisciplinary improvisation workshops, involving making-with musical instruments, playdough, bodies, and objects intra-active relational intensities between bodies (human and more-than-human) were re-visioned and re-constructed.

These two cases deliberately bring together differences (in location, disciplines, time, modes of engagement, cohorts) including working across the physical and digital, thus widening the notion of ‘body and materiality’ as thing-power beyond the human. However, the two projects also shared several commonalities. These most notably being the students who were at the very early stages of considering careers in education, with both groups still heavily engaged in disciplinary practices, languages, and concepts, and expected disciplinary ways of enacting their subjects.

Both projects also focused on following the shifting relations afforded by thing-power, attending to the affective entanglements between things, place, bodies, technologies that emerged. In both projects, we followed the same methodological approach of deliberately playing with modulating the different intensities of somatic sensing, and in so doing ‘troubling’ (Haraway 2016) expected disciplinary modes of engagement. The science project deliberately modulated sensorial experiences away from the disciplinary norms of sight, through which scientists commonly describe, define and label their objects, in order to foreground the affordances of touch and sound; whereas the music project deliberately played with feel and touch to create different intensities of experience, feeling the vitality of material, beyond only paying attention to sound (and the making of ‘correct’ sounds). It is through these deliberate modulations in sensorial experiences within these particular disciplinary spaces, that this article advances nuanced understandings of how ‘thing-power’ and ‘making-with’ contribute to affective encounters with materialities within the classroom.

While each project was designed and conducted independently, with data collated by the authors

with the consent of the students involved, they were brought together into a ‘rhizomatic encounter’ (Deleuze and Guattari 1987) with each other, through the process of re-reading and co-writing. Such an encounter allows the projects to be set in motion together, through our writing together, allowing for diffractive pattern analysis, and ultimately by bringing attention to how new patterns emerge in their ability to make something happen (Bennet, 2010).

Diffractive readings

The process of seeing patterns of commonalities and difference ‘together’ is what we refer in posthumanist terms as diffraction, which is not a comparison, but a process of superimposition: the diffractive waves meet and create interferences resulting in different patterning, but also in amplifying patterns, whereby waves meet and join to become stronger and more noticeable. Following Murriss and Bozalek (2019), we particularly attend here to instances of productive disconcertion occurring at those points when ‘displacement’ yields the possibility of an affective experience, unfolding at the point of interference of past experiences of either teaching music or science. and the present invocation, emerging as the difference that ‘makes a difference’. Murriss and Bozalek (2019) described disconcertion as moments of temporal diffraction, whereby different levels of temporality collide: for example, the usual linearity of information delivery afforded by a digital medium, that being the projection of an image or sound on screen, is interrupted by the slowness and circularity of tactile sensing; and equally, the adept and familiar playing of an instrument ‘on the fingers’ expands into a multiplicity of new gestures, engulfing a heterotopy of materials. Barad describes temporal diffractions as ‘travel hopping’ (In Murriss and Bozalek 2019, p.1511), in which we can ‘re-turn’, ‘re-work’ and ‘re-connect’ past with the present, to re-see “how entangled relationalities that do not appear to be proximate in time or space, constitute a force” (p.1510). Through re-reading the cases, together, our temporal diffractive analysis, which advances understandings of how this methodological approach can allow us to re-see sensorial / material encounters, aims to illuminate the similarities and differences of our projects, the amplifications, and interferences they create between them when they encounter and speak to each other, as evidences of thing-power and making-with across different disciplinary spaces.

Case One: Touching Vital Materialities in Science Education

Between 2021 and 2022, the course *Methodologies for Teaching in the Life Sciences* ran online due to Covid constraints. The students all based in Italy, attended online classes from home, or from a teaching room in the University. The lecturer, responsible for a specific section of the programme, taught the course in the Italian language from her home in the UK.

With the emphasis on ‘methodologies’, the course had the double aim to introduce students to methods for teaching life sciences, but also to reflect on the nature of scientific knowledge itself. In this paper, we focus on two instances of the course, based on two sequential teaching moments in which we explored ‘the nature of living things’. Each teaching moment made use, respectively, of *a visual methodology* (van Boeckel, 2020), via the use of images of biological objects projected on PowerPoint slides; and *a touch methodology* (Springgay, 2018), via the manipulation and feeling of material objects accompanied by mark-making on paper.

Living or non-living?

In the first activity, groups of students were given photographs of various natural objects, either as wholes or as parts; some were presented in their wider context (e.g., a tree in a woodland) and at different stages of the life cycles (e.g., egg and chicken; seed and plant). The task was to

categorise objects into living or non-living things, with a view to identify common characteristics for describing a living thing and to build a model of a living system. While images of whole organisms appeared straightforward and easy to categorise as living things (e.g., tree; egg; seed), the parts of former living organisms raised points for discussion. For example, a mussel shell was immediately categorised by the students as non-living, although it was previously part of a living thing. The justification appeared to lie with the thing-power of the *material*: the shell that was largely constituted by inorganic matter (mineral part) was set in opposition to the organic material of the creature that would have previously inhabited it. Similarly, the dead trunk of a tree in which several communities of birds had found their home was classified as non-living, while the birds were the living part. While applying this logic of inorganic-dead and organic/live, the photograph showing the stump of an old, woodland tree hosting a large community of mushrooms (Fig 1) caused the greatest confusion.



Figure 1 Tree stump with a community of puffballs on Corstorphine hill, Edinburgh (photo taken by the author)

As mushrooms are commonly known in biology for their role of ‘decomposers’ of decayed matter, there was no doubt in the mind of the students that it was them that were to play the part of the living amongst the debris of decaying wood. The problem arose when they were invited by the lecturer to consider the ‘invisible’ part of the mushrooms, the extensive network of invisible hyphae, forming the underground mycelium that stretches for miles under the soil. Recent studies have pointed to the mycelium as the most important system of communication and exchange of nutrients within an ecosystem, regulating the flows of accumulation (sinks) and release (source) of materials, directed to a dying or a damaged tree elsewhere in the forest, and connected to the network. When viewed from this perspective, the stump (Fig 1) is more than an inert surface – or substrata - upon which mushrooms or other creatures might grow. *As thing-power, the stump is itself the evidence of an assemblage*, a coalition of things that are brought and kept together – and well beyond the singular stump itself- in affective-associative mutuality of relationships. Wohlleben (2017) described this associative confederation as in the power of keeping other things alive (Box 1), even at some distance, and enabling an apparently dead stump to shoot new branches from another species of tree (Figure 2).



Box 1

“Living cells must have food in the form of sugar, they must breathe, and they must grow, at least a little. But without leaves – and therefore without photosynthesis- that’s impossible. No being on our planet can maintain a century-long fast, not even the remains of a tree, and certainly not a stump that has had to survive on its own. **It was**

Figure 2 Stump of a beech tree shooting new branches of birch tree on Corstorphine hill, Edinburgh (photo taken by the author)

The dualistic, assertive, and almost clinical analytical logic the students acquired after many years of instruction in the natural sciences clashed with the possibilities offered by another way of looking at life and the process of living. As the discussion pushed against the idea of a living thing as an object or bounded organism, their scientific education was

challenged by questions of vitalism and animism which they saw as different from the scientific concepts of *synergy and community* that are well-known in ecology. It was apparent after the discussion of the quote by Wohleben that students viewed *biological objects* as things that may come into contact within a community, but they would not be perceived as intra-acting objects that exist as making-with in entanglements with one another.

Dewey (1933) described how the sense of vision as connected to the ‘evident’ or in plain view, has come to dominate in Western culture, overshadowing the fuller range of sensorial perceptions. The use of technological devices in education emphasize vision and reduced the sense of touch to the much simpler act of pointing or tapping a surface with the fingertip. Yet, as Dewey (1933) maintained, vision not only is integrated with other senses, but it receives its direct extension of meaning from connection with other senses, but especially with the experience of ‘touch’ and ‘sound’. Both these senses counteract the ‘distant’ with the ‘near’, the ‘forewarning’ with the ‘impending’, for in the “impending there is always an aura of indeterminateness and uncertainty – all conditions favorable to intense emotional stir (Dewey 1933, p.246). A change of sensorial modulation was thus introduced in the second part of the exercise, moving away from vision to afford the touch-ful observation of the nature of living things.

Attunement as touch-ful encounters in science

Students were asked to find a natural object in their own home, that being a shell or a plant that they kept close by. Taking the lead from a recent study where drawing was used as part of an anatomy class in Higher Education (Reid, Shapiro, and Louw, 2018), the exercise began with a mark-making activity designed not to ‘produce a product’ but to ‘intensify the sensing’ of the hand. Through *mark-making*, students were practicing with applying pressure, feeling the response of the paper, either in absorbing or smudging the graphite; make ‘sfumato’ effects to feel and activate the

granularity of the surface as well as the hardness and softness of their pencils. While vision remained available to them, it was both *touch and sound* that organised students’ perception of their actions on the paper, as they mostly worked in silence, creating small sketches on the undertone of the rustling, smoothing, and scratching of the paper.

In the second part of the exercise, they were guided to close their eyes, exploring their object through their hands with a view to make a sketch of it afterwards. The activity invited them to extend the range of *sensorial stimulations* using all parts of the hand and the sensorial affordances of their skins. At the end of the activity some students shared their impressions while others reported their experiences in a reflective activity later. Their comments point to some striking differences in the ways they related to and approached their apparently ‘dead’/inorganic organism:

“This mode of observation allows to go beyond what we might say is a ‘static’ vision of the object... I believe it makes understand better some intrinsic characteristics that before, when we looked at it in a rush, had not been able to notice” (EP).

While the observation of an *object* for specific features is common practice for naturalists, this experience was different in the way it opened their perception to how other organisms ‘come to be felt’ by us (e.g., smooth finger versus rough surface). Through the ‘difference that makes the difference’ as Barad (2007) would say, the students did not look for something they expected to see but were inviting the feeling of how the object ‘conducted itself’, responding in real time to the idiosyncratic movements of their handler (Bennet, 2010, p.59): “... *then I understood that the invitation was to revisit something that is almost spontaneous and taken for granted for a naturalist, that is the different modalities through which we can ‘enter into contact’ with natural things*” (MT).

As *thing-power* is activated through *touch experience*, such encounter is not simply with something other, tangentially moving on the skin surface, but also with oneself and one’s own ability to feel the diversity of *sensations*. For example, in Figure 3, another student spoke about having felt relaxed and “*having re-discovered the pleasure of drawing with pencil*” (RG).

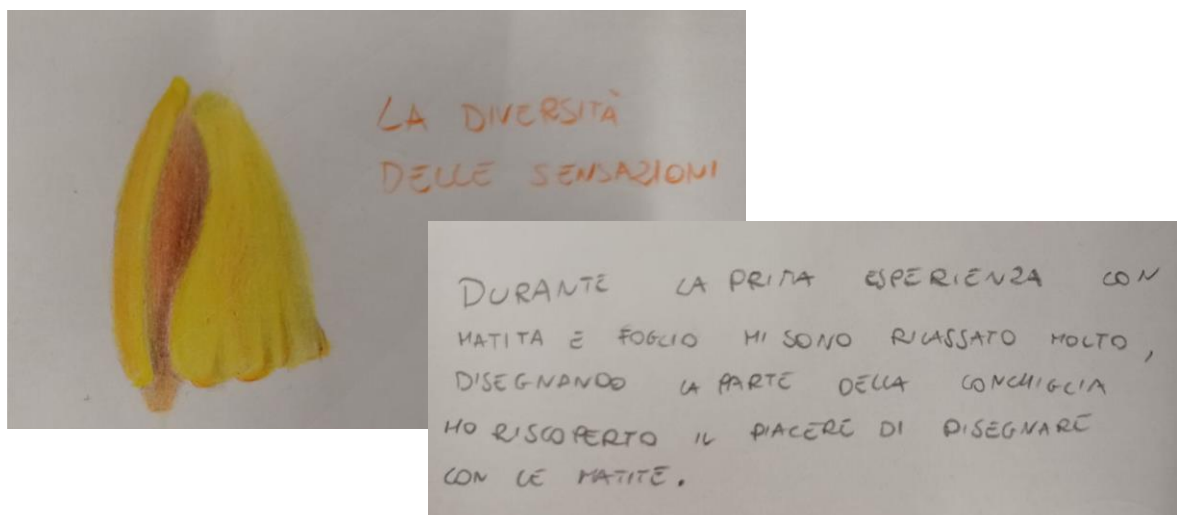


Figure 3 The diversity of sensations

In the re-discovery of the affective force of touch in intra-action with thing-power, a ‘travel-hopping’ as Barad (2007) would describe it, illustrates the diffractive temporality of the past flooding into the present, and bringing forth a new ‘collective’ (Bennet, 2010, p.57).

Almost seeing with new organs of perception, activating sensorial attunement also re-positions the students towards their objects of inquiry, bringing forth an imaginative dimension that reveals the object as something new:

“I was imagining the microscopic structure of the plant and I observed the details that in theory I know well and that I could recount, but when observed with the pencil, they took a whole new different aspect to my eyes. Something more that was before.” (EG)

Not simply a tool for the execution of plans, the use of the pencil in the science space was both and at the same time de-familiarising observational practices, and de-territorialising them across disciplines and settings (home space/University space; childhood/maturity).

Moments of disconcertion further appeared as they talked about the difficulty to translate their *tactile perceptions* into words. For example, in the drawing of the leaf (Figure 4), it is notable the *use of tonality* and the *tentativeness of the lines* which seem to accompany the tentativeness of the students’ own words. EG speaks of ‘the absence of lexicon’, troubling their own aptitude towards labelling and classification: *“so much so that in describing my object I looked more for analogies”, searching for a “new vision” given to us by these “experiments”. Utilising the sense of touch entailed a change of point of view, which enabled us to see new characteristics of these objects. In my case, I could see some light undulations present on the leaf (EG).*

Figure 4 Use of tonality in pencil drawing of the leaf of a houseplant.



This choice of language was in visible contrast with the assertiveness and deliberateness encountered in the earlier exercise. Conventionally, the process of *scientific observation* is mediated by the collection and computation of data as information about something that exists outside in the world; but as Keller (2003) beautifully articulated, another opportunity exists. By taking a detailed look at the process of “informing” and breaking it into its constituent parts: *informing*, the process is one by which ‘the observer’ enters into the object of consideration, concentrating attention fully inside of the object, becoming *informed*, or *inside of the object*, doing whatever the object is doing, and during that imaginative process, what the object is doing is revealed to you. “This is such an intimate process”, Fox Keller continues, “that, although the results you receive are describable, the very process you used to acquire the results is ineffable and therefore indescribable” (Keller 2009).

In the *transdisciplinary enactment of science*, thing-power was set into motion as an affective confederation of *materials and relations* across times and spaces. *Foregrounding the senses, both as a means to touch and of being ‘touched’ by the world* (Barad, 2009), the linear narratives of knowledge consumption were disrupted and troubled, transcending disciplinary boundaries and opening up different possibilities for being and making-with bio-digital material.

Case Two: Touching Vital Materialities in Music Education

The group of UK music student teachers assembled, in the music classroom, with their course leader and PhD student. While some were undergraduates and some postgraduates, all the students were studying towards Qualified Teacher Status, through a combination of professional studies, music pedagogy modules, and school placements. The PhD project, the focus of this section, sat alongside these course experiences, inviting students to engage in conversations, workshops, and reflections on ‘teaching as improvising’. Improvising was considered in the project as ‘a radical apparatus’ (Murriss 2016) through which notions of power, control, teacher, knowing and skill, were all ‘troubled’ and remade together.

Threaded throughout these transdisciplinary enactments (with music, theatre, play, collage) was the constant presence of the embodied ‘habits’ of the music student teachers. Years of canonic/traditional musical performance and linear, individualised enactments of education were imprinted in their bodies, and as a consequence was evident in their language, conceptual frameworks and visualisations (Figure 5).



Figure 5: Imprinted embodied ‘habits’ of piano and guitar playing whilst talking

Habits, as a “settled tendency or usual manner of behavior” (Merriam-Webster, n.d), are inextricably connected to the stories we tell about pedagogical practices we enact (Haraway 2016), disciplinary concepts and theories which we embody (Lenz Taguchi 2010), and the entanglements that we make-with in ‘becoming teacher’ (Cooke 2021). They shape our relationships with(in) human and more-than-human entanglements, creating fast trajectories of action and response, which feel familiar, comfortable, and known. However, this comfort, is also accompanied by a narrowing, a homogenous set of responses, in which different movements, different knowings and different encounters with ‘things’ and their *power*, can be pushed aside for a less troublesome course of action.

The focus of the transdisciplinary workshops was therefore to open up these *embodied habits* to re-making, to disrupting and displacing attention away from habitual practices to allow a broader view of music/improvising/education/practices. By entangling ourselves with *materials*, both expected (e.g., musical instruments) but also unexpected (e.g., playdough, everyday objects, theatre games) such displacement not only allowed different languages, conversations, and descriptions to occur, but also allowed different relationalities to develop. These experiences are shared here as two illustrations.

Illustration 1: The thing-power of playdough in the music classroom

During the workshops, we explored images of children playing and discussed improvising as a form of collaborative physical play, leading to making-with playdough. The introduction of the playdough was conceived as a way of opening up conversations around improvising, creating new

shared experiences as a catalyst for ‘going beyond’ habitual responses within music improvisation frames. However, it became clear during the activities that this was far more than a catalyst for conversation, whereby the thing-power of the playdough disrupted habits, displaced attention, and deterritorialized disciplinary concepts and language. The playdough *did* this, not through creating linguistic frames, but through intensifying the groups sensing abilities while improvising, where the constant reverberation of bodies *with* the materials led to ‘felt’, “in-forming” relationships (Keller 2003).

The sensorial-material *qualities* of entangling with playdough in the music classroom led to a heightened consciousness of its disjunction with the disciplinary boundaries of the space. For some, the appearance, the initial vision, of the playdough pots into the space caused great excitement. For others its presence, its power to travel in small pieces, its smell and feel, created moments of uncertainty. The indeterminacy and uncertainty of the playdough elicited a response, a moment of disconcertion as past memories and experiences of playdough started reverberating (Figure 6).

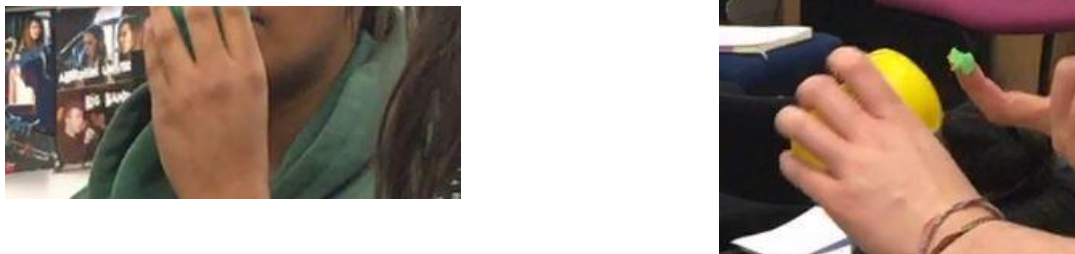


Figure 6: Initial encounters with the playdough

The students responded to the immediacy of the material’s ability to make-with them. Together they (playdough+human+table) made shapes, movements, and offerings. The playdough didn’t let them go, getting under their fingernails, falling on their shoes, or showing the imprint of their fingers. This immediacy of entanglement, whereby human and material cannot help but ‘become together’ in obvious ways, modulated the groups perceptions of improvisatory acts, and ‘troubled’ existing embodied habits, in several ways.

We witnessed entangling with playdough and each other in collaborative physical play. We also witnessed the ‘troubled’ enlightenment views of ‘bounded individualism’ in which we consider ourselves “independent of others...liv[ing] in [our] own world, alone, free and responsible only to [our]self” where “we are fundamentally differentiated from others” (Aspelin 2011, p.7). As seen in Figure 7, the thing-power of the playdough, its ability to morph and change with the different bodies and spaces, created lived experiences of “tentacular thinking” which Haraway (2016) explains as “a life lived along... a wealth of lines” in which we (humans and more-than-humans) make “attachments and detachments...cuts and knots...weav[ing] paths and consequences but not determinisms” (Haraway 2016, p.31-32).



Figure 7: Constantly moving together to make-with entanglements

This entangled encountering, where everything and everybody is on the move created spaces for sensing the way *with* the materials, in rhythmic variations. Again, *foregrounding the senses, both as a means to touch and of being ‘touched’ by the world*, the playdough acted as a rhythmic body with our own rhythmic bodies. With the playdough’s inherent squeakiness as it moved fingers to fingers, fingers to surfaces, the group were provided with sonic, sight and felt information about their intra-active relationship with the playdough and what could be achieved (Figure 8). These are not merely rhythmic repetitions creating a pulse, although a pulse is there, but are as Springgay (2016) notes “variations, characterized by speeds and rests...[as] a differential patterning that emerges through the relations between things... [where rhythm is] concerned with potentiality, immanence and newness” (Springgay 2016, p.74).



Figure 8: Immanent rhythms of touch

This rhythm of variation, of exploring potentiality, disrupted embodied notions of control and power-over materials, something which was deeply embedded in the musical enculturation of the group. This tension was explicitly stated by the group in comments such as “*Arghh I haven’t touched playdough for like hundreds of years*”, “*I need to get the technique...what’s going on here?*”

All of this points to a broader concern about gaining skills alone, through practice, outside of the entanglement, *before* performing disciplinary roles and professional practices such as we know and expect of ‘teacher’. This was most explicitly expressed when the playdough wasn’t doing as they wanted (as above) but also in relation to anxieties about working in a new school the following year, “*I think it’s going to be quite hard in probation year because...I’ll be using a lot of new materials, so I’ll be winging it*”. This notion of pre-skill before performing, embedded, and embodied deeply within art music pedagogies, was re-seen when playing with the playdough, with one member of the group reflecting that, “*the playdough let me do some of my ideas but sometimes it didn’t, and I changed what I was doing*”.

By playing with playdough, the group (re)felt the potentiality of the material to act on them, on their habitual practices and on their disciplinary assumptions. To think-with, make-with, and become-with, rather than have human agency over a material relationship, created the spaces to allow new thinking/doing/talking into the music classroom.

Illustration 2: Soundings as radical sensing

Sound is the central experience of music pedagogies. However, little attention is given as to what sounds ‘do’ in educational spaces, and how sound works as a form of sensorial entangling or making-with others (human and otherwise). As with the material habits of power and control evident in our playing with playdough, embodied habitual responses were forced open within our

workshops where our experiences foregrounded the thing-power of sounds. Creating spaces to explore sound making processes with unfamiliar materials (keys, water bottles, pens, coffee cups) displaced attention from habitual responses and instead made us pay attention to the vibrant resonances of sounds as constantly travelling, reaching and touching (Figure 9).



Figure 9: Concepts of instruments on the move as a key plays the cymbal

This displacement and disruption to embodied habits was most evident in sequences of musical improvising, with objects that disrupted disciplinary notions of ‘instrument’. However, these disruptions weren’t only seen through the eye, or felt through the vibrations of the material in the hand alone, they were felt through the reverberations in their bodies, where “sensing is always...a feeling-oneself-to-feel” (Nancy in Steintrager and Chow 2019, p.193). In this way, the reverberations of sound do more than enter the ear and make the eardrum resonate, giving the brain information, as is the view promoted widely in music education, but instead the reverberations amplify the *(whole-)body sensing*. Gershon and Ben-Horin (2009) talk of the paradox of being lost and found simultaneously in the musical moment. We can be lost in the processes of making-with, where the whole body is engaged and responding with the sonic, material, bodily entanglements that are unfolding, but where also we are constantly finding ourselves, through feeling ourselves feeling, as a process of in-the-moment sensing our own positioning in that entanglement.



“In this short 5 second sequence the materials lead what is being created. Both M and S change how they are playing their materials (the guitar on S’s lap and the water bottle M is holding), and what they are playing (S changes to playing the table and a drum to his side) as a critical and creative response” (Research notes 2018)

Figure 10: Sensing materiality of sound

This is a *sensing of sounds as a material process* which Kontturi, argues “necessitates giving up the comfort of positioning, the reliance on preconditioned knowledge and a pre-chosen political viewpoint.” (In Springgay 2016, p.76).

In these two illustrations, the students through allowing themselves to *make-with*, rather than *impose themselves onto* materials, allowed the thing-power of the materials to reverberate throughout their

whole bodies, where these reverberations were *felt* across past experiences, habitual ways of responding and in-forming relationships in the present. These reverberations of the body re-made models and conceptualizations of improvising, the role of teacher, the nature of instrument and the nature of skills within making.

Envisioning Future-Making Educations

In both projects, students, encultured into particular views of knowing and ways of enacting their disciplinary roles (as teachers, learners, scientists, musicians), were offered experiences to enact modes of knowing differently, *foregrounding the senses, both as a means to touch and of being ‘touched’ by the world*, all of which foreground different potentialities for sensorial engagement. These experiences allowed both groups of students to make-with their sensing bodies. The entanglement of associating differently with materials as the materials associated with them, moved them from the habitual mode of seeing objects against a background (Bennet, 2010), those being biological or musical concepts and entities, to recognising the thing-power involved in their being and becoming. This saw them both inter-acting and intra-acting with and beyond the disciplines, and with and beyond the teaching frame of digital interfaces, transgressing their own and other’s assumptions, norms and disciplinary boundaries.

What matters when we invite posthumanism in Teacher Education?

In both cases, conventions of disciplinary learning and teaching were troubled. Students attending *both* courses were expecting to be taught the fundamentals of learning ‘how to teach’, whereby materials and tools often take an instrumental role in the effective delivery of information or deployment of a skill (e.g., musical performance or investigative practice). Such delivery function was further emphasized in the Italian setting, when at that time, the digital medium was both instrumental and necessary. Nevertheless, in both cases, the experiences of the students were fundamentally enacted via *affective and tactile associations of vital materialities* as Hickey-Moody (2020) remarked, as “stories that unfold through making”, and which are deeply textured and sensorial as ‘felt’ on the skin. To begin with, both cases put into evidence that students were strongly ‘pulled’ by their specialist disciplinary habitual ways of responding, where the Science students were ‘pulled’ by habitual ways of seeing and linguistically framing their experiences, and the music students were ‘pulled’ by strongly embedded conceptual understandings of music, improvisation, and the role of the teacher. These ‘disciplinary pullings’, as moments of tension, disconcertion, and revelation, were ‘productive’ in that they created momentum in a different-than-imagined directions. In both cases, students *felt* the temporal diffraction of their past and present, the childhood experiences of comfort from drawing and manipulating playdough flooded in and fed into their future self. There was no longer a separation between them as teachers and them as younger learners: an affinity and an intimacy with materials – making-with – collapses onto a plane of affinity for others and other than humans, whom they may come to teach and themselves being taught by. Hence, following Massumi (2002), the evidence from these projects together point to making-with as **care-full and sense-full attending to the relationalities of all sensorial modes with materialities**. Making-with the entanglements and allowing thing-power to express itself, was only possible by inviting sensing bodies to explore beyond and deeply within the relationships being created, in more-than habitual, disciplinary ways. As a result, both projects created spaces in which the tactile materialities of the two disciplines were re-conceptualised beyond the logic of digital instrumentality, and the immediacy of already established models and concepts, to recover the fullness of *body sensing*, as *touch* extended over the entire skin, as an essential *mode of knowing*.

While focusing on the *body sensing* and *the tactile*, the diffractive re-reading of the two projects unexpectedly surfaced the potential of *sound as a key element of being 'in touch'* with the world - and with each other - including our material partners. Each group experienced how sound – of unusual instruments such as the pencil pressing on the paper, or key on cymbal - could enable them to 'feel themselves feeling', generating an intimacy of experience. Because of the *power of sound to generate 'direct emotional expression'*, due to its immediacy and different qualities, Dewey (1933) talks about music, as both the highest and the lowest form of the arts, enabling the lyrical as well as the plain ordinary. Interestingly, such power of putting people 'in touch' with their own human nature - being much less profiled in the sciences (van Boeckel, 2020) - began to appear in our science project as a distinctive relational feature, which significantly changed the affective quality of the online space. Similarly, in the music project the impact of sound on the ways we build relationships with materials wasn't only evident with musical instruments, as conceived by the group, but was also evident in how rhythmic variation played a part in developing a playful, exploratory mode of making-with different entanglements. These sequences of engagement encouraged the students to understand one's own sensations, feeling the resonances of their bodily / material / digital vibrations across *timespacematter* (Barad 2007).

It is here, in this space between and beyond disciplinary linguistic frames, that temporal diffraction offers us the opportunity to see/hear/feel/touch learning as fundamentally and radically occurring through the sonic qualities of thing-power. Through this sound sensing, as fundamental to allowing the world to touch us as well as us touching it, we create spaces which afford significant changes in ontological stance. From acting powerfully *over* our material partners in already made sequences of making, to embracing the uncertainty, vulnerability, and mutual partnership of making-with the vital materialities and their potential to enrich and expand the conventional analytical view and bringing musicality to the fore. Such findings also yield a surprising insight shifting common ideas of the 'digital' away from technological efficiency to recover the fundamentally and radically human ability to sense one's being in relationships.

These findings contribute to advancing a nuanced posthuman understanding of transdisciplinary education; the diffractive re-reading of our practices point to the significance and importance of the search for a more nuanced and transgressive language to bridge shared human experiences of worlding together, beyond disciplinary subjects. In doing so this article advances understandings of thing-power and making-with as contingent on touch-ful, body-sensing encounters which modulate and disrupt disciplinary boundaries. It also contributes insights which are important to considerations of digital learning and education, positioning bio-digital cultures as contingent on *a touching* that goes beyond the fingertips; *an attuning* beyond the machine, and its *intertwining and interaction* in the world and with others. The *vital materialities* of thing-power and making-with bodies - such sensorial attunement - is a profoundly political act, counteracting the hegemonic influences of digital capitalism. It is the **careful attending to the relationalities of all sensorial modes** – uniquely engaging sensing bodies - that generates thing-power.

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References

- Allen, A. (1999). *The power of feminist theory: domination, resistance, solidarity*, Boulder, CO: Westview Press.
- Aspelin, J. (2011). Co-Existence and Co-Operation: The Two-Dimensional Conception of Education. *Education*, 1(1), pp.1–6.
- Barad, K. (2007). *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Duke University Press, Durham.
- Barad, K. (2012). On touching-the inhuman that therefore I am. *Differences*, 23(3), pp.206–223.
- Bennett, J. (2010). *Vibrant Matter: A political ecology of things*. Duke University Press, Durham.
- Braidotti, R. (2019). *Posthuman Knowledge*. Polity Press, Cambridge.
- Burnard, P., Colucci-Gray, L., and Cooke, C. (2022). Transdisciplinarity: Revisioning how science and arts together can enact democratizing creative educational experiences. *Review of Research in Education*, 46(1), pp.166-197.
- Castañeda, L., & Selwyn, N. (2018). More than tools? Making sense of the ongoing digitizations of higher education. *International Journal of Educational Technology in Higher Education*, 15(22).
- Cooke, C. (2021). *‘Troubling’ Music Education: Playing, (re-)making and researching differently*. University of Edinburgh PhD Thesis, Unpublished.
- Davies, R. and Trowsdale, J. (2021). The culture of disciplines. Reconceptualising multi-subject curricula. *British Educational Research Journal*, 47(5), pp.1416-1434.
- Davis, B., Towers, J., Chapman, O., Drefs, M., & Friesen, S. (2020). Exploring the relationship between mathematics teachers’ implicit associations and their enacted practices. *Journal of Mathematics Teacher Education*, 23, pp.407–428.
- Decuyper, M., Grimaldi, E., & Landri, P. (2021). Critical studies of digital education platforms. *Critical Studies in Education*, 62(1), pp.1–16.
- Deleuze, G., & Guattari, F. (1987). *A thousand plateaus*. Athlone.
- Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process*. Boston, New York: D.C. Heath and company.
- Gershon, Walter S. and Ben-Horin, O. (2009). Deepening Inquiry: What processes of making music can teach us about creativity and ontology for Inquiry based science education. *International Journal of Education & the Arts*, 15(19), pp.1-37.
- “Habit.” *Merriam-Webster.com Dictionary*, Merriam-Webster, <https://www.merriam-webster.com/dictionary/habit> (accessed 21.6.2022).

Haraway, D. J. (2016). *Staying with the Trouble: Making Kin in the Chthulucene*. Duke University Press.

Hickey-Moody, A. C. (2020). New Materialism, Ethnography, and Socially Engaged Practice: Space-Time Folds and the Agency of Matter. *Qualitative Inquiry*, 26(7), pp.724–732.

Keller, E. F. (2003). *Making sense of life: Explaining biological development with models, metaphors, and machines*. Cambridge, MA: Harvard University Press.

Keller, E.F. (2009). *A Feeling for the Organism — Life and Work of Barbara McClintock: A Evolution of Consciousness ARJ2 Review by Bobby Matherne*. <http://www.doyletics.com/arj/afeeling.shtml> (Accessed 15.8.22).

Klein, J. T. (2015). Reprint of “Discourses of transdisciplinarity: Looking back to the future.” *Futures*, 65, pp.10–16.

Lenz Taguchi (2010). *Going beyond the Theory / Practice divide in Early Childhood Education: Introducing an intra-active pedagogy*. Routledge, Oxon.

Massumi, B. (2002). *Parables of the virtual: Movement, affect and sensation*. Duke University Press.

Merleau-Ponty, M. (1968). *The visible and the invisible*. Northwestern University Press.

Moss, P. (2014). *Transformative change and real utopias in early childhood education: A story of democracy, experimentation and potentiality*. Routledge, London.

Murris, K (2016). *The Posthuman Child: Educational transformation through philosophy with picture books*. Routledge, London.

Murris, K., & Bozalek, V. (2022). *In conversation with Karen Barad: Doings of Agential Realism*. Routledge.

Murris, K., & Bozalek, V. (2019). Diffracting diffractive readings of texts as methodology: Some propositions. *Educational Philosophy and Theory*, 51(14), pp.1504–1517.

Murris, K., & Muller, K. (2018). Finding child beyond ‘child’: A posthuman orientation to foundation phase teacher education in South Africa, in Bozalek, V., Bradotti, R., Shefer, T., & Zembylas, M. (eds.). *Socially Just Pedagogies: Posthumanist, Feminist and Materialist Perspectives in Higher Education*, pp.151-171. Bloomsbury Academic.

Parke, E. C. and Plutynski, A. (2020). *What is the Nature of Theories and Models in Biology?* In K. Kampourakis and T. Muller (Eds). *Philosophy of science for biologists*, pp.55-79. Cambridge: Cambridge University Press.

OECD. (2020). *Curriculum Overload: A Way Forward*. OECD Publishing, Paris, <https://www.oecd-ilibrary.org/sites/c4cff4cd-en/index.html?itemId=/content/component/c4cff4cd-en> (accessed 15.8.2022).

Reid, S., Shapiro, L. and Louw, G. (2018). How haptics and drawing enhance the learning of anatomy. *Anatomical Sciences Education*, 1-9, pp.164-172.

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Russell, A. W., Wickson, F., & Carew, A. (2008). Transdisciplinarity: Context, contradictions and capacity. *Science Direct Futures*, 40, pp.460–472.

Springgay, S. (2016). Towards a rhythmic account of working together and taking part. *Research in Education*, 96(1), pp.71–77.

Springgay, S. (2018). ‘How to Write as Felt’ Touching transmaterialities and more-than-human intimacies. *Studies in Philosophy and Education*, 38(1), pp.57–69.

Steintrager, J.A. and Chow, R. (2019). *Sound objects*. Duke University Press, Durham and London.

Stewart, S. (1993). *On longing: Narrative of the miniature, the gigantic, the souvenir, the collection*. Duke University Press.

Szabó, T.P., Burnard, P., Harris, A., Fenyvesi, K., Soundararaj, G., Kangasvieri, T. (2021). Multiple Creativities Put to Work for Creative Ecologies in Teacher Professional Learning: A Vision and Practice of Everyday Creativity, in: Lemmetty, S., Collin, K., Glăveanu, V.P., Forsman, P. (eds) *Creativity and learning: Palgrave studies in creativity and culture*. Palgrave Macmillan, Cham., pp.115-143.

van Boeckel, J. (2017). Artful empiricism and improvising with the unforeseen: Two approaches in seeking understandings of nature through art. In S. Asikainen, C. Brits, K. Plebanczyk, L. Mijatovic and K. Soini (Eds), *Culture in sustainability: Towards a transdisciplinary approach*, pp.143-160.

van Boeckel, J. (2020). Linking the missing links: An artful workshop on Metamorphoses of organic forms, in Burnard, P and Colucci-Gray, L (eds) *Why Science and Art Creativities Matter: (Re)configuring STEAM for Future-Making Education*. Brill Sense Publications, Leiden, pp.245-269.

Williamson, B. & Komljenovic, J. (2022). Investing in imagined digital futures: the techno-financial ‘futuring’ of edtech investors in higher education, *Critical Studies in Education*, 1-16, pp.2-16.

Wohlleben, P. (2017). *The hidden life of trees*. London: Generic.