

ARTICLE

Entanglements of matter and meaning: The importance of the philosophy of Karen Barad for environmental education

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Abstract

The rich and innovative ideas of quantum physicist and feminist theorist Karen Barad have much to offer environmental educators in terms of practical theories for teaching and learning. This article shares insights gained from a facilitated conversation at the Australian Association for Environmental Education (AAEE) Conference Research Symposium, and offers an introduction to Barad's theories for environmental educators. At this time of challenging planetary imperatives, environmental education is increasingly called upon to contribute to students' understanding of connectedness, and Barad's theory of *agential realism* provides a way to think about, articulate and engage with connectedness as inherent within the world rather than something we need to create. By considering *entanglement* as a fundamental state, we understand that separateness is not the original state of being. This shift in perspective supports a subtle yet powerful approach to knowledge, communication and collaboration, understanding difference as integral within the world's entangled becoming. The convened conversation sought to explore Barad's thinking by defining and discussing the concepts of *agential realism*, *intra-action*, *material-discursivity*, *phenomena* and *diffraction*. Barad's ideas were used to collectively explore what it means to be intraconnected and entangled in today's world, and specifically how these concepts and experiences relate to our work and lives as environmental educators and researchers.

Keywords: Karen Barad; environmental education; environmental education research; agential realism; diffraction; intra-action; phenomena

As environmental educators and researchers, it is clear that our work is urgent and compelling. We know *why* we continue to question, reframe, teach, guide and act: our very lives and the existence of our earth eco-systems depend on this work. However, *how* to do it is much more complex. 'Creating Capacity for Change' was the theme of the Australian Association for Environmental Education (AAEE) Conference and Research Symposium, which gave us an opportunity to explore the *how* through the work of quantum physicist and feminist theorist Karen Barad, who states, 'We are not outside observers of the world. Neither are we simply located at particular places *in* the world; rather, we are part *of* the world in its ongoing intra-activity' (Barad, 2007, p. 184). *Intra-action* expresses interior relationality that is always already occurring, in contrast to *interaction*, which describes the relationship between separate entities.

In pursuit of the *how*, and while becoming more and more entangled in these ideas through our various strands of research, work and life, we offered to convene a conversation at the AAEE Conference Research Symposium. Our goal was to expand the conversations of our Barad study group through a collective exploration of Barad's understanding that we are 'part *of* the world' (Barad, 2007, p. 184), as expressed through the theory of *agential realism* and how it has the

potential to inform and enliven every aspect of our individual and collective work as environmental educators and researchers. How might we use the terms and concepts of Barad's work to continue to build the ideas and language we need to engage our students in understanding how connected everything really is? The purpose of this article is to continue the rich discussion that emerged from that symposium conversation through sharing the insights that were gained.

Writing about the conversation collectively through a Baradian lens adds layers of dynamic complexity and troubles our ingrained notions of causality and individual ownership of knowledge. We acknowledge that Barad's concepts shake our foundational ontological and epistemological perspectives, as we understand that knowledge is not outside of us waiting to be found, discovered or created by one person in isolation, but is something that is generated in relationship with each other and the environment (Barad, 2007). We focused on Barad's use of the concept of *diffraction* to pay attention to the overlapping ripple patterns of knowing we create together. We diffractively read 'insights through one another in attending to and responding to the details and specificities of relations of difference and how they matter' (Barad, 2007, p. 71). This is a very different approach than the extremely individualised and competitive neoliberal space we may be used to as educators and academics. Barad's approach places difference as an expression of entanglement's multiplicity, rather than absolute separateness (2014). In opening our collective engagement with Barad's theory of agential realism even wider to include your (our readers') participation, we extend ourselves to a new place of understanding: a place-time where knowing is alive in the connectivity between us, and not simply frozen in these marks on the pages of this article.

Initial intra-actions becoming

Agential realism evokes the generative intra-actions it expresses, with the queering of all boundaries as indeterminate in nature. This makes it difficult to hold a position of absolute individualised separation while engaging and knowing with Barad's work. Each reading and discussion of Barad's work is a new and re-newed iteration of intra-active entanglement, a perpetually unfolding knowing and becoming with/in the material-discursive phenomena of our lives and learning (see later section for further explanation of *material-discursivity*). This entanglement includes here the intense and often poetic writings of Barad, especially in her seminal work, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (2007). Thus, the intentional interweaving of many direct quotes throughout this article gives Barad's work voice while offering the reader the space to engage with Barad's knowledge and theories with us, as we delve into the implications of these theories for environmental education.

Through engaging with agential realism, our Barad study group expresses intra-active relational generativity by learning together and each of us applying our learning to our own PhD research. Our PhD topics are varied, with Shae exploring the use of a patterns-based approach to teaching, learning and applying participative complexity thinking and understanding; Lisa exploring collective storytelling that helps us understand lived experience; and Simone delving into teachers' perceptions and practices of childhoodnature.¹ These differences enable rich layers of depth in our animated conversations and unfolding understanding of Barad's concepts. Our process of learning and knowing, relating and being, bringing forth who we are, is constantly emergent as we consider the very nature of what it means to be human. We think about how we can understand/experience the *response-ability* within our entangled inseparability; with response-ability being a thought provoking and expansive concept from Haraway that implies 'collective knowing and doing, an ecology of practices' through our capacity to respond (Haraway, 2016, p. 34). Barad (2007) defines all human practices, including conceptualising, as material and therefore cogenerative within phenomena; in other words, there is responsibility inherent within all action.

Agential realism is a broad theory based in the quantum physics of a Bohrian ontology, whereby intra-actions create all matter and entities from *within* foundational phenomena, expressing the continuous entanglement of humans and world together/apart (see discussion in Barad, 2007, p. 67–70). This perspective of grounding in quantum physics challenges the traditional Newtonian idea of the world made of separate parts that dominates much of Western ontology. Boundaries of being, knowing, acting and becoming then express themselves through patterns of diffraction (Barad, 2007). When the three of us meet together physically or virtually, diffractive patterns of discussion and sharing are generated, where the ripples within our generative engagement both enhance one another as resonance and cancel one another out as dissonance. Barad's writings are part of the generativity, with their marks of mattering, emanating agentic relationality, *meeting us halfway*.

In agential realism's reconceptualization of materiality, matter is agentive and intra-active. Matter is a dynamic intra-active becoming that never sits still ... Matter's dynamism is generative ... in the sense of bringing forth new worlds, of engaging in an ongoing reconfiguring of the world. (Barad, 2007, p. 170)

With agency of its own, our learning and knowing rippled out beyond its three-person dynamic, and sharing our entangled and diffractive process with others became inevitable. The entity of our creative generativity sought evolving expression, and the AAEE Conference Research Symposium presented a timely opportunity. The theme of the symposium was 'Creating Capacity for Change'. As Barad states clearly that the agential realist framework 'provides a posthumanist performative account of technoscientific and other naturalcultural practices' (2007, p. 32), we felt that a conversation on the relevance of Barad's theories would be an appropriate addition to the forum.

Sharing the innovative and multifaceted ideas of Barad was a challenging task for a 90-minute workshop. When we consider a phenomenon such as a research symposium through the notion of intra-action, 'a lively new ontology emerges: the world's radical aliveness comes to light in an entirely non-traditional way that reworks the nature of both relationality and aliveness (vitality, dynamism, agency)' (Barad, 2007, p. 33). Our intention for our forum conversation was to try a new way to explore the possibilities for developing a collective awareness of our agential participation with/in the phenomena of knowledge production and of the impact it has on our actions and practice as educators. A positivist perspective views humans as essentially separate entities who must have knowledge downloaded into them, much like data onto a hard drive. An approach such as Barad's may be an important and game-changing path to participatory, relational and generative knowledge building in environmental education and research, given that we need new and creative ways of relating with others (including nonhumans) within environmental education to promote socio-ecological justice.

In planning the workshop, we sought to enact emergent conditions in which participants could embody knowledge to apply in their own work and/or life context. We were not there to present rhetoric, or explain what we 'knew', but to open our own learning and re-learning, our diffractive relationality with Barad's work and each other, to a collective engagement with other environmental educators and researchers, and indeed also with the other-than-human phenomena that also existed in that space. With the understanding that we are always already entangled, and that the boundaries between 'knower' and 'known' are not fixed, we hoped that the conversation would act to open the possibilities for response-ability with/to each other's being and becoming, learning and knowing, as environmental educators, researchers, colleagues. As Barad writes: 'Knowledge making is not a mediated activity, despite the common refrain to the contrary. Knowing is a direct material engagement, a practice of intra-acting with the world as part of the world in its dynamic material configuring, its ongoing articulation' (Barad, 2007, p. 379). We further address the implications of this for environmental education towards the end of this article.

Agentially realising agential realism

Note to readers: in the following description of the workshop, no individuals have been identified or singled out. The discussion summaries are approximate and reflect the entangled nature of the session.

The university classroom that had been designated for the Research Symposium session was a double room — long and narrow. Participants meandered in from morning tea, some with cups still in their hands, and sat mostly around the edges. A steady flux of people, some known to the presenters and others not known, contributed to expectation through presenter-participant intra-activity. After an acknowledgement of Country and a brief scene setting — introducing ourselves and Barad's work — we sat down in the front of the room in a small semicircle of three chairs facing each other to discuss agential realism, just as we would in our monthly study group.

Although the conversation at this point was three-way, we were aware that the intra-activity of bodies (both human and nonhuman), and all other phenomena — with place itself participating and enabling — also existed between all present. Even those not present materially (including Barad), contributed to configuring this particular phenomenon called 'Research Symposium Session'. As Barad (2007) writes in the preface to *Meeting the Universe Halfway*: '... time and space, like matter and meaning, are iteratively reconfigured through each intra-action, thereby making it impossible to differentiate in any absolute sense between creation and renewal, beginning and returning, continuity and discontinuity, here and there, past and future' (p. ix). Our venturing forward was 'new' for us and simultaneously a discontinuous continuation of an unfolding of knowledge. Barad's ideas are explored through the following conversation, in a similar way to the discussion about agential realism that the authors shared during the Research Symposium session.

Shae: I understand agential realism as 'an appreciation of the intertwining of ethics, knowing, and being' (Barad, 2007, p. 185). It is an inclusive inseparability that Barad describes as an ethico-eco-onto-epistemology. This intertwining brings responsibility, so there is always an ethical dimension to everything we do in the world. Barad describes all knowledge making, and all actions really, as having a material effect, because we are entangled; inseparable with/in a co-generative world. Life is not all happening 'out there', happening is ubiquitous everywhere, all the time. In this way all elements of life, across the boundaries of human and nonhuman, living and so-called non-living, all of it, have agency in a way that is active and entangled. It is so different from the perspective of classical science where the world is 'made' of interacting but still separate parts.

Simone: Yes, and I see agency as not taught, learned or obtained as a human possession: it just is. Agential realism includes the notion that every-thing is intra-acting, and therefore expresses agency. This is not something we have conceptually understood in our lives because we have a tendency to base life primarily on seeing separate entities. Barad's is an understanding that life is dynamic beyond the conceptions of Newtonian physics. Agential realism describes entangled agency as always already happening.

Lisa: Atomic theory pushed us into this idea that we are all discrete individuals with boundaries. What Barad's philosophy of quantum physics then lets us understand is that those atoms are in fact intra-action in-action; they are formed from fundamental phenomena and always forming new emergent phenomena. There are no absolute boundaries — we are entangled!

Shae: It's taking us to a place of all of life being dynamic. Everything is perpetually wiggling and moving — 'fluctuating' is the word used in physics — nothing is still, and everything actually has a vibrant quality to it. All things are in a dynamic state of intra-acting rather than the

classical physics viewpoint that matter is inert. Barad states that there is inherent agency within the intra-active dynamics.

Lisa: *This has so many implications for the idea of personal agency, and our work as educators. We are accustomed to seeing agency as a skill set that needs to be taught to students. This asks us to see agency as something much more than that, as inherent in everyone and everything. Which as educators brings us to consider how agency is expressed and enacted, or how it might be denied or silenced.*

Barad: *'Agency, in this account, is a much larger space of possibilities than generally considered. The reworking of exclusions entails possibilities for (discontinuous) changes in the topology of the world's becoming. But not everything is possible at every moment' (Barad, 2007, p. 182).*

Simone: *Everything is possible 'but not everything is possible at every moment'. This is just so important as we reconfigure our ideas of personal agency . . .*

Barad: *'Interior and exterior, past, present, and future, are iteratively enfolded and reworked, but never eliminated (and never fixed). Intra-actions reconfigure the possibilities for change. In fact, intra-actions not only reconfigure spacetime-matter but reconfigure what is possible. Ethicality is part of the fabric of the world; the call to respond and be responsible is part of what is. There is no spatial-temporal domain that is excluded from the ethicality of what matters' (Barad, 2007, p. 182).*

Lisa: *This inspires me! I understand this to mean that ethicality exists as an integral part of all that is — it is not an optional extra. This supports the foundational ideas of environmental education being not only 'about' the environment, but also 'for', 'in' and 'as' the environment. We are the environment as well.*

Barad: *'Questions of responsibility and accountability present themselves with every possibility; each moment is alive with different possibilities for the world's becoming and different reconfigurings of what may yet be possible' (Barad, 2007, p. 182).*

Shae: *Oh yes, realising the indeterminate nature of life, not as a fixed thing, but coming into being through intra-actions in every moment, brings me to experience that the next thing I say or do is an agential enactment with/in everything that is coming forth. Every moment is then full of responsibility, if we just stop and understand that life is this process of 'mattering', being brought forth as we engage with/in it. Not in the way that humans create reality, but as integral within it! I love the integration of matter and meaning in Barad's use of these words. It sure is another level of responsibility and response-ability, so different from being responsible for something fixed that already exists 'out there'.*

Simone: *It's a complete reconceptualisation of what sustainability and environmentalism is all about — it brings it to a different level. A place where what you do affects the all. It impacts every thing. Not just in this vicinity, but in all timespace. This makes sense. The agency and responsibility of everything we do — every thought, action and movement — matters. How we respond to situations and thoughts becomes the responsibility. The response-ability: the ability to respond in a way that is for more than the siloed human 'I', towards considering the co-generative dynamics of human and nonhuman agency in timespace. Our human responsibility is then not only to the nature 'out there' but becomes about our relationality with every thing.*

Lisa: *So 'agency' in agential realism emerges from that response-ability . . . I wonder why the expression 'realism' though? Perhaps to emphasise the 'realness' of materiality?*

Shae: *Yes, I think previous positivist materialist theories saw matter as dead, inert, and only moving or progressing when acted upon, in a linear cause and effect kind of way. And then there was a swing toward constructivism, which in its extreme view places human thinking and*

language as constructing reality. It seems to me that Barad brings a re/newed perspective, with everything, all of life, as a dynamic intra-active enactment, and with all entities — everything — having the agency of existing through difference that is relational, and inherent capacity to generate effect. Also, it means that the human is decentred from the omnipotent observer position, to be once again — well, always already — mutually entangled with/in everything.

Lisa: Yes! And agential realism rethinks the fundamental concepts of binary thinking, like living and not living, conscious and inert, human and nature. Barad explains that quantum physics has shown us that that the same bit of matter can be seen as both a particle and a wave, in different circumstances (see Chapter 3 of Barad, 2007). This has rocked our foundational view of the universe as an either-or proposition. It turns into an ‘and-and’ proposition! It is something tangible for people to understand and work with. This would include the notions of matter, discourse, subjectivity, causality, agency, space and time. All those concepts can be stuck in binary thinking and agential realism helps us rethink them in a non-binary relational way.

Simone: For many of us in the Minority (‘Western’) world, we haven’t yet embodied what this means in daily lives — it doesn’t come into our everyday awareness — that this is the way that life comes into being.

Shae: I think Barad’s call is for Science, and for all of us really, to engage meaningfully with the ramifications of the quantum entanglement of material/discursive mattering across all scales. Although I know that Barad considers the notion of ‘scale’ to be a way of thinking that can mask internal connectivity. Whilst there are clear differences in the language and conceptual approaches, Barad’s work also broadly corresponds with the understanding within Indigenous Knowledge of the mutual and perpetual coming-into-being of all entities with/in Country. I read the 2017 work of Brian Martin recently, an Indigenous scholar who has also made this connection. It’s interesting that there are areas of concurrence between Barad’s ideas and some aspects of Indigenous Knowledge.

As this intra-action between the three of us came to an end, the other workshop participants were invited to more actively engage with each other and us by moving into three smaller groups. The intention for each group was to consider a facet of the theory of agential realism: intra-action and phenomena, material-discursivity, and diffraction. We now turn to a diffracting of the workshop through these three lenses — and the entanglement of each one of us in our respective group.

Lisa intra-actively intra-acts phenomenon

... the notion of intra-action recognizes that distinct agencies do not precede, but rather emerge through, their intra-action. (Barad, 2007, p. 33)

Six humans gathered around a rectangular table on one side of the large rectangular room to learn collectively, with ‘phenomena’ and ‘intra-action’ the focus of discussion. There was a large sheet of paper in the middle of the table, with some markers scattered over the centre. There was a pile of photocopied sheets that included excerpts from Barad’s *Meeting the Universe Halfway*, with the font of the subtitles carefully chosen to mirror the cover of the actual book. We read off the sheet to define phenomena: ‘... phenomena are the ontological inseparability/entanglement of intra-acting “agencies”. That is, phenomena are ontologically primitive relations... relations without pre-existing relata’ (Barad, 2007, p. 139).

While some of us in the group knew each other, we had never gathered as a group before, in that place, to engage with Barad’s work. Through the phenomenon of a research symposium, we were trying to individually and collectively understand how our previous understandings

of the term ‘phenomena’ meshed with this new suggestion that we were all already entangled within-and-as phenomena ourselves, in our very being. As we talked, we developed the understanding of ourselves as intra-actional in nature; forming new configurations of phenomena; in this case, a ‘discussion group’. Some of the group asked questions, others added their thoughts, a few sat silently observing. The table sat solidly in the middle; the markers were picked up by a few people and used to write generative thoughts on the paper, then set down again. Conversation from the other groups buzzed in the background. The entanglement of all these actions and words contributed to the uniqueness of this discussion, the unfolding of phenomena, which could not have happened anywhere else, with anyone else, at any other time. We went on to read off our identical sheets about ‘What is intra-action?’:

The neologism ‘intra-action’ signifies the mutual constitution of entangled agencies. That is, in contrast to the usual ‘interaction’ which assumes that there are separate individual agencies that precede their interaction, the notion of intra-action recognizes that distinct agencies do not precede, but rather emerge through, their intra-action. It is important to note that the ‘distinct’ agencies are only distinct in a relational, not an absolute, sense, that is, agencies are only distinct in relation to their mutual entanglement; they don’t exist as individual elements. (Barad, 2007, p. 33)

The discussion turned towards the interconnectedness of all things, and how this is reflected in the ecosystems of the natural world, and indeed our bodies. We mused on the fact that our human bodies are made up of more microbiotic cells than human cells, in continuous intra-action, and we explored how this idea, were it more widely understood by most humans from an early age, would greatly affect our current (so-called ‘Developed World’) mentality of individualism. For example, in the Australian National Curriculum, the Science content for the Foundation Year is based on understanding that ‘Living things have basic needs, including food and water’, and the content for Year 1 is based on ‘Living things have a variety of external features’, including objectives such as ‘recognising common features of animals such as head, legs, and wings’ and ‘describing the use of animal body parts for particular purposes such as moving and feeding’ (ACARA, n.d.-b) But what if our youngest school students, instead of learning about individual beings and body parts and plants, began their ‘science’ learning with lessons on the foundational relationality between living things, and between living and nonliving things? We would have a more collective understanding from an early age. In other words, in many ways we are always already a multitude; or, as Barad describes, always already a differentiated becoming with/in the phenomena of life, whereby absolute boundaries do not exist (Barad, 2007). In the group, we continued on to consider how environmental education may be enhanced by the agential realist view that the differentiating boundaries we are accustomed to could be viewed instead as entangled phenomena, therefore embodying meaning and inherent response-ability.

‘Phenomena . . . come to matter through this process of ongoing intra-activity’ (Barad, 2007, p. 336). In questioning, pondering and discussing in language as well as being receptive to each other’s nonverbal communications — in this intra-active material-discursive space — we collectively widened our preconceived ideas of human/other-than-human relationships. The becoming-with that this space engendered now had the potential to ripple out into our respective responsibilities as educators, family members, and humans acting in the world.

Simone meets material-discursivity

What is needed is a robust account of the materialisation of all bodies — ‘human’ and ‘nonhuman’ — including the agential contributions of all material forces (both ‘social’ and ‘natural’). (Barad, 2007, p. 66)

Barad (2007) provides an answer to this call in developing the concept of material-discursivity. In Barad's account, discursive practices are part of the entangled material conditions of the world. Through a diffractive mix of new materialism, science studies and quantum physics theory, Barad describes all material bodies, both human and nonhuman, as agentially involved in material-discursive enactment, that is, agentic participation and contribution as integral within phenomena. As we sought to explore these ideas with/in our group, both conceptually and tangibly, cause and effect became impossible to position. With butcher's paper and markers in hand, we moved, each of us and together, through the workshop room, and gathered around some pushed-together tables in a circle to explore the meaning and mattering of the term *material-discursive*, and how it might look in environmental education practice.

The conversation began by reading prepared sections from Barad's (2007) work specific to the (re)conceptualisation of material-discursivity. Our group sought a way of learning, being and becoming together in a space where there was little preconceived familiarity with the topic, uncovering the vulnerability of navigating the unknown as a collective. Being very different from the humanist position of people as the 'central measure of all things' (Barad, 2007, p. 136), or the constructivist view of language being the measure of what is 'real', material-discursivity required us to expand our ideas of knowing. We moved our thinking away from the Cartesian separation of knower and known towards 'knowing-together-with' matter and each other as mutually agentic in participation. The language of agential realism can be quite complex for those new to it, with Barad aiming to avoid the reductive pitfalls of representationalism by placing theorising and writing itself as part of the material-discursive mattering of the world. Barad does not shy away from creating new terminology when current words fail to express an intended meaning. Engaging with Barad's work requires being open to understanding the happenings and matterings of the world and the universe in a different way, as foundationally intraconnected from within.

Delving into Barad's philosophy of the quantum nature of matter opened us to an exploration of how matter can and does come in/to being through material-discursive practices and how these matterings matter. We considered the perspective that 'materiality has an agentic and productive factor in its own right' (Barad, 2007, p. 225). Through this 'meeting with' matter, materiality can be re-envisioned to open our thinking to the possibility of meaning being inherent in everything that we are part of bringing forth and/or excluding, in our engagement with/in material-discursive processes. In this way, discursive practices are far more than acts of speech, in Barad's words:

Discursive practices are not anthropomorphic placeholders for the projected agency of individual subjects, culture, or language. Indeed, they are not human-based practices. On the contrary, agential realism's posthumanist account of discursive practices does not fix the boundary between human and nonhuman before the analysis ever gets off the ground, but rather allows for the possibility of a genealogical analysis of the material-discursive emergence of the human. (Barad, 2007, pp. 149–150)

We philosophised, explored and adventured into new becomings, unique to that timespace and woven through with all entangled moments before and those to come. In this process of navigating, space opened for sharing, listening, observing, considering and growing our ideas: entangled becoming in-action. We contextualised material-discursive meaning through the lived and embodied dynamics and experiences of our daily work and life practices. We stretched our perception beyond the traditional representations of speaking and listening, into the significance of the relationality of everything that exists with/in all we do as material discursive practices. Not just the story of individual people, but the stories of matter — stuff, objects, spaces — *every thing*, acknowledging the perpetual iterativity of material-discursive practices in the process of the world's becoming, that is, how every moment in the classroom is so complex with/in everything that is taking place. In other words, considering that *the story of matter, matters*.

It is difficult to imagine how psychic and sociohistorical forces alone could account for the production of matter. Surely it is the case — even when the focus is restricted to the materiality of ‘human’ bodies (and how can we stop there — that there are ‘natural’ not merely ‘social’ forces that matter. Indeed, there is a host of material-discursive forces — including ones that get labeled ‘social,’ ‘cultural,’ ‘psychic,’ ‘economic,’ ‘natural,’ ‘physical,’ ‘biological,’ ‘geopolitical,’ and ‘geological’ — that may be important to particular (entangled) processes of materialization. (Barad, 2007, p. 66)

Barad’s use of the word ‘discourse’ as discursivity repositions its common use (as a fixed language-based representation) through the lens of quantum theory, and contributes to a (re)conceptualisation of the relationality of discourse and matter as an ongoing becoming. This includes an ‘account of the materialization of all bodies — “human” and “nonhuman” — including the agential contributions of all material forces (both “social” and “natural”)’ (Barad, 2007, p. 66). In this account Barad defines discursivity as not ‘requiring intellection in the humanist sense’, but rather as the world articulating itself through integrated material-discursivity (2007, p. 149). We questioned how this inseparability influences and impacts the way we understand, know and feel with the world, particularly how we understand classrooms and learners. We wondered about becoming more aware of the complexity of intra-actions, with the learner and classroom as more than ‘products’ of what is happening at face-value. Material-discursivity describes these dynamics and acknowledges that there is no end: only an ongoing and reiterative unfolding of phenomena.

Our sharing diffracted through our group’s knowing and we emerged expanded, considering ways of being that included awareness and perception of our entangled becomings. In the time-space that this encounter offered, we expressed our journey together through the material-discursive terrain in verbal and written language with markers and paper, back to the larger group when we reconvened.

Shae diffracts diffraction

... a diffractive methodology is a critical practice for making a difference in the world. It is a commitment to understanding which differences matter, how they matter and for whom. (Barad, 2007, p. 90)

Our group engaged with Barad’s use of the word diffraction. Settling into chairs around a large table we began with reading some quotes from *Meeting the Universe Halfway* (Barad, 2007), together with a few points on meanings of the term *diffraction*, prepared on a paper handout that also showed a simple image of a diffraction pattern (see Figure 1).

First, we considered the literal meaning of diffraction. The ripple pattern we see forming when a pebble is dropped into water is described as diffraction. When two pebbles are dropped, a diffraction pattern of the relationality of the ripples from the two pebbles is formed, with some ripples synergising into peaks and some co-cancelling into troughs. This overlapping waveform can be described as interference in a field, as illustrated in Figure 1. We then considered how the concept of diffraction could be used both metaphorically and practically in our teaching practice. Describing both phenomena and as a methodology, diffraction illuminates the indefinite nature of boundaries (Barad, 2007), and brings attention to the enactment of those boundaries. What is included and what is excluded are highlighted (Barad, 2014). In this way diffraction denies absolute exteriority (separateness), defining difference as marked from within (Barad, 2007, 2014). In terms of difference ‘a diffraction pattern does not map where differences appear but ... where the effects of difference occur’ (Barad, 2014, p. 172). We shared our thoughts about how Barad’s ideas highlight that actions, both material and discursive, generate difference. Making difference relational rather than being a property of an entity.

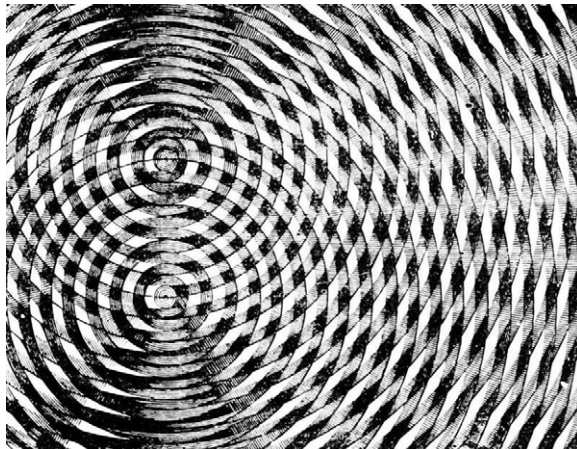


Figure 1. Superposition of two wave systems, in 'Water-Waves and Sound-Waves' by Joseph Norman Lockyer, *Popular Science Monthly*, Volume 13, June 1878. Public domain. http://media.aphelis.net/wp-content/uploads/2013/09/LOCKYER_1878_Superposition_of_two_wave_systems.jpg.

All matter is described by Barad as diffractive on a quantum level, a principle illustrated in *Meeting the Universe Halfway* with an image of a steel razor blade whereby there really is no edge as such, but rather a diffractive rippling between 'blade' and 'not blade' (Barad, 2007, p. 76). Barad informs us that diffractive relationality is the fundamental state that generates 'individual entities' as difference, through internal dynamics described as intra-action. Agential realism thus places connectedness as the default state, and offers diffraction as the process of all becoming. This quantum process that is always already occurring at every level of life is described by Barad as 'the world's differential becoming' (2001, p. 91), being life's fundamental dynamics of the connectedness of entanglement, and differentiating described as 'cutting-together-apart' into entities, in a dynamic of perpetual becoming (Barad, 2014). According to Barad, it is a process that has no 'outside'; it is a process that we cannot be external to.

In engaging with Barad's work, it became obvious to us that it is not easy to express such an intra-actively connected world using the linear cause and effect language of English, a language that reflects the reductionist Newtonian paradigm of life made of simple separate parts, and the Cartesian separation of subject and object. After exploring diffraction as a fundamental process, we turned to thinking about its use as a metaphor and methodology. Haraway (1985) first described diffraction as an optical metaphor that is useful for making a difference in the world. It is an approach to engaging with meaning making through relationality, which can be expressed as interference, reinforcement and/or difference. In this way a diffraction metaphor can be used for paying attention to the 'between'; the relational dynamics and resulting effects that Barad describes as the objective materiality of marks on bodies. The word 'bodies' here means matter, including the bodies of entities, both human and nonhuman.

In our Conference conversation the diffraction of focus was the relating and relational meaning being generated by us as we discussed and embodied Barad's work; a focus that contrasts with attention to the individual as the fundamental centre of meaning. Being, knowing and learning were continually and communally reconfigured as we engaged with the concept of diffraction as a way of communicating with each other across moving difference; a place/being/enactment 'composed from interference patterns' (Haraway, 1992, as cited in Barad, 2014, p. 172). In this way knowledge became an alive, shared dynamic, not a preformed, 'correct' and external objectivity. We understood that fixing things in our ideas and definitions was a habit of mind that could be dissolved in the engagement of diffraction as methodology. This was a new

approach, particularly for anyone used to holding the space of being the knower. The level of response-ability to each other and our shared experience increased in our group as this awareness grew with/in us. We wrote notes on large paper, marks of what mattered in our moment. Moving back in/to the whole room, we chose to express our diffractive experience of intra-active-becoming-in-knowing through collective movement, some making waves of embodied communication that aligned with another's movement, building 'peaks' of synergy and energy, while others were 'cancelling' each other out, forming 'troughs' of dissonance. We noted that it was interesting how the boundaries of 'self' and 'other' could soften, enabling 'I' and 'them' to emerge in/to a concurrent murmur of 'we' and 'us'.

Diffractive understanding offers a perspective of connectivity through Barad's view that shows that:

The point is not to simply put the observer or knower back in the world (as if the world were a container and we needed merely to acknowledge our situatedness in it) but to understand and take account of the fact that we too are a part of the world's differential becoming. (2007, p. 91)

And, unlike the perspective that 'reality' is constructed from human attention or language, in using the metaphor of diffraction to engage with knowledge making and meaning making we are reminded that we are 'materially engaging as part of the world in giving it specific material form' (Barad, 2001, p. 91). Applying diffraction as a methodology and method in education generally, and in environmental education in particular, may provide a starting point to consider relationality as inherent in the classroom with differences generating agentially from within such connectivity, through our agential actions, as agential cuts within everything we enact. This understanding can then ripple further towards considering such relationality on a wider scale.

Agential realism and environmental education

Theories are not sets of free-floating ideas but rather specific material practices in the ongoing intra-active engagement of the world with itself, and as such they are empirically open and responsive. That is, they are always already part of what the world does in its ongoing openness and responsiveness to itself. (Barad, 2011, p. 5)

We regathered from the small groups back into a whole group in order to share before moving out into the Conference, and the entanglement of phenomena that was and is our personal lives. Subsequently, we wondered together, how did the agential cuts that were enacted through our workshop diffract out into the world? How could the theory of agential realism be immediately and specifically applied to environmental education and research? What effect might be generated? Through our post-workshop collective study, we identified four main ripples of agential realist theory that have great relevance to the praxis of environmental education.

1. Agential realism helps us to fracture binary thinking. 'According to classical Newtonian physics, everything is one or the other: particle or wave, this or that, here or there. Quantum physics queers the binary type of difference at every layer of the onion' (Barad, 2014, p. 174).

In their analysis of environmental education research, Gough and Whitehouse (2003) wonder how innovative environmental education can actually be, if it continues to dwell within the 'powerful binary discourses holding a "humanised identity" firmly in place' (p. 38). These binary human discourses extend their reach into all aspects of educational practice, forming limited and limiting ideas and stories of human versus nature, male versus female, black versus white, and mind versus body. Agential realism's basis is non-binary, as well as describing all matter as

diffractional in nature, which could influence the methodologies and praxis of environmental education at the very core. In a nonbinary and diffractive approach, our enactments are *always* making new (re)configurations of becoming. We want to acknowledge the multiplicity of contingent entanglements, as well as our own embodied perspective, to consider all aspects of a phenomenon. We see any learning experience as being inclusive of *all* elements, human and other-than-human. All we include and exclude ‘matters’ in all senses of the word; this is a central tenet of Barad’s agential realism. We are all always already participating in the unfolding of the knowledge and action happening all around us. There is inherent responsibility in this relational view. This understanding could bring us towards feeling our entangled inseparability with ‘others’ as not-other, self as not a separately fixed individualised ‘self’, but self as natureculture, and nature-culture as self (Haraway, 2003). We are no longer humans versus the natural world; we are inseparably with/in/as the world. This notion challenges many anthropocentric, mechanistic and technicist ideologies that inform many current sustainable development goals. Agential realism rejects the focus on achieving only outcomes and instead iterates response-ability to the agentic process of becoming that acknowledges each element and facet as significant in the reconfiguring of the whole.

2. Agential realism helps us to understand that interdisciplinary learning could (should?) be the foundation of all educational praxis. In an interdisciplinary educational paradigm, the space opens up for new directions for environmental education. In their book *The Socioecological Educator*, Wattchow *et al.* (2013) argue that ‘the world badly needs citizens who can see and work in inter-disciplinary ways’ (p. 207). The authors argue for systems of education that support the understanding that no discipline stands alone, and that a holistic and interconnected approach is key to meeting current world challenges. While most educational systems are built on scaffolding that does not yet allow these interdisciplinary approaches to come to fruition (Olvitt, 2017), could current educational practice be turned on its head by reconfiguring the curriculum? In other words, instead of breaking it into smaller pieces of siloed learning as is currently practised, could we consider all learning as always already an intraconnected whole?

Not only is the world too complicated for any one set of disciplinary considerations to do justice to the complexity of the issues — although I believe that is surely the case — more importantly, a continued insulation of different (inter)disciplinary practices from one another risks missing some crucially entangled epistemological, ontological, and ethical issues. (Barad, 2011, p. 4)

There is an aspiration in the current Australian National Curriculum towards an interdisciplinarity of sorts, with environmental education funnelled across different disciplines via the cross-curriculum priority of ‘sustainability’ (ACARA, n.d.-a). Sustainability as a cross-curriculum priority allows it to be taught across and through all key learning areas, and in doing so facilitates the implementation of authentic interdisciplinary learning approaches. This is a start; however, agential realism supports the understanding that interdisciplinary learning cannot be just relegated to a side note that will ‘enrich the curriculum’ and ‘enable the delivery of learning area content’ (ACARA, n.d.-a). If we adopt the understanding that all life is agentic intra-actions with/in phenomena, with the differencing of bodies arising with/in entanglement, then learning cannot be siloed into always separate ‘learning areas’.

Through fracturing the segregations and separations established in traditional single disciplinary approaches, learning can be grounded in real-life situations through intra-actions with all agential beings. This inspires a different perspective about how sustainability and other learning areas are approached, and invokes a different and more immediate kind of responsibility, a response-ability. Which leads us to our third suggestion of how agential realism is relevant to environmental education.

3. Agential realist theory helps us to understand and work with agency as potential that always already exists in an entity, both human and nonhuman — rather than something that needs to be received or obtained from outside sources.

In my agential realist account of mattering, responsibility is not an obligation that the subject chooses, but rather an incarnate relation that precedes the intentionality of consciousness. Responsibility is not a calculation to be performed. It is a relation always already integral to the world's ongoing intra-active becoming and not-becoming. That is, responsibility is an iterative (re)opening up to, an enabling of responsiveness. (Barad, 2012, p. 81)

Educational practice based in an ethico-eco-onto-epistemological perspective of agential realism can enable us to evolve from thinking we need to 'achieve' agency and reconnection to nature, to an understanding that agency is an ongoing potentiality with/in every moment, and that connectivity — and the responsibility that entails — are inherent. Human beings always have the potential to enact their inherent agency. We can also then ask ourselves a series of questions that destabilise the narrowly humanistic concept of agency. Can we consider environmental education from the question of 'How does this insect, plant, animal, bird, tree, human express agency?' Questions such as 'How is this river, person, tree, rock, animal excluded from mattering?' can remind us that entanglements are fundamental. With all of life expressing ongoing agency, we can ask: 'What are the dynamics and relationships of this entity's being/becoming?' Rather than the reductive categorising of 'What is it', 'What does it look like', and 'How can we use it', we can ask: 'How is it entangled?', and 'How is it differentiated?' In this way, we understand agency as the potential and actualising of intra-acting entanglements with/in phenomena. Responsibility — response-ability — permeates such an approach.

4. Agential realism helps us question everything . . . , which is what we need to do in this time and space.

Agential realism does not start with a set of given or fixed differences, but rather makes inquiries into how differences are made and remade, stabilized and destabilized, as well as their materializing effects and constitutive exclusions. Since cuts are understood to be enacted rather than given (it is the cut that makes the individual and not the other way around), all manner of questions regarding the nature of mattering come together here — that is, questions of matter in the multiple senses of meaning, being, and valuing. (Barad & Kleinman, 2012, p. 77)

At the opening forum for the AAEE Conference Research Symposium, environmental educator and researcher Paul Hart challenged researchers to integrate environmental education research more deeply with social education theories and discourses, utilising 'complexity as a bridge' (Hart, 2018) to enable this integration. Hart further proposed for the use of post-methodologically driven and data-based theories; research not only based on data collection and analysis but rather theoretical frameworks such as new materialism to capture 'what is really going on' (Hart, 2018). There was a call to read more, read further and to play outside the field by extending ourselves beyond our discipline. This call can clearly be answered through the agential realist framework developed by Barad. It enables the asking of questions that dig deeper than 'What needs to be done next?' or 'How do we address the urgent signs of the Anthropocene?'² Agential realism offers a way to question how intraconnected becomings and beings come to matter, in both meanings of the word. This view begins with entangled connectivity as foundational and opens towards understanding the agency we all have in the exclusions and inclusions of matterings in the world. (Barad, 2017). This questioning is crucial in that it helps us understand the multiple entanglements of our current global situation. It questions the very nature of nature in offering possibilities for changes that matter now.

Conclusion

'Meeting the Universe Halfway' is a part of that longstanding tradition in feminist science studies that focuses on the possibilities of making a better world, a livable world, a world based on values of co-flourishing and mutuality, not fighting and diminishing one another, not closing one another down, but helping to open up our ideas and ourselves to each other and to new possibilities, which with any luck will have the potential to help us see our way through to a world that is more livable, not for some, but for the entangled wellbeing of all. (Barad, 2011, p. 8)

We had planned our Research Symposium conversation with the understanding that any material-discursive experience had the potential for rippling out into the actions and praxis of the workshop participants, with/in the sphere of environmental education, research and beyond. The significance of this is also at a more global level, with the awareness that there are enormous issues and challenges for humans and all life on Earth at this juncture. Recognising the urgencies of the current environmental and political challenges, and the resulting imperative for clear information and action, we therefore kept in mind the complexity perspective that seemingly insignificant actions can contribute to significant effects. The always already entanglement of agential realism reminds us that all of our actions matter. Everything is enactment. It is an approach that places our responsibility as inherent and can inform environmental education, first by helping us identify the impact we have with each and every enactment, and second by assisting us in the 'tracing of entanglements' (Barad, 2017, p. 108), of classroom, school, community and beyond.

Barad's theories help us to consider education in general and environmental education, in particular through a diffractive entanglement of becoming and learning. This is less about representing 'the world' through abstract notions of knowledge and describing what needs to be thought and done with regard to 'the other', but rather it is more about being in the fullness of relationality with self-other, human and nonhuman, in immediate becoming/knowing. The theory of agential realism helps us start where we are right now, through response-ability with/in this place and all other entities near and not so near. Our entanglements and response-abilities are not separate. We do not have time as a human species to merely discuss and reflect on the connectivity needed; we need to live it and be it, letting it permeate through our way of understanding self and other, both human and nonhuman. 'What is at stake is nothing less than the possibility of change' (Barad, 2007, p. 46). We see this possibility of change as situated at the core of environmental education practice and research.

Endnotes

1. Childhoodnature is a posthumanist theory where childhood and nature are not separated by timespace, but co-exist in a dynamic process of entanglement: a state of being and becoming. See the *Research Handbook on Childhoodnature* for more information (Cutter-Mackenzie-Knowles, Malone, & Barratt-Hacking, 2018).
2. The 'Anthropocene' being the geological epoch named after the human-induced changes to the earth (Crutzen & Stoermer, 2000).

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As a grandmother, Shae L. Brown has a firm resolve to contribute to the skills and understanding that young people need for the C21. Bringing insights from a career in education to her doctoral project, Shae is responding to the fact that complexity thinking and understanding is considered to be a central skill for the times of turbulent change that are here now and ahead. Drawing on pattern understanding Shae is engaging Barad's agential realism diffractively with Indigenous Knowledge and Complexity Theory, to generate a conceptual and practical approach for students and educators.

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