WANDERING WITHIN, AGAINST, AND BEYOND THE PATHWAYS OF SCIENCE
EDUCATION: TOWARDS HEEDING THE CALL OF INDIGENOUS SCIENCE

by

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Abstract

Often within science education, Indigenous science is either excluded or included in ways that differ from or defer its intended meanings, as well as its pedagogical potentiality for all students. The central question that guides this dissertation is How is Indigenous science to-come with/in the context of science education? This dissertation draws from decolonizing, post-colonial, post-structural, and post-humanist theory-practices to address ‘to-come’ in three ways: a) Indigenous science on its own terms as not-yet and still-to-come with/in science education; b) Indigenous science as a relationship whose indeterminate arrival invites re(con)figuring of the lived constructs, concepts, and categories of science education; and c) practices (including pedagogy) that might allow for and nurture the possibility of Indigenous science to-come in its second iteration.

To explore this triple(d) understanding of ‘to-come’, each chapter within the dissertation acts as an excursion through a path of science education. Journeying involves strategically straying off the beaten path or tactically taking the pathway in unintended ways to lose sight of the prescriptive and often problematic ways in which the path is regularly travelled. Further, each journey is iterative, travelling through, against, and/or beyond a particular path, wherein the learning is enfolded and carried forward into the next trip.

Equipped with a plethora of deconstructive tools, science education is (re)opened through (re)considering its: a) oppositional, dialectic nature; b) critical modes as protective, rather than productive, of the status quo (i.e., through mirrored correspondence); c) ontological taken-for-grantedness (e.g., through its a priori and singular positioning); and, d) responsibility, as well as ability to respond. In response, I offer a call and analytical frames for: a) dialogue; b) critique as prismatic and diffractive; c) ontological plurality and co-constitutiveness; as well as, d) response-ability, respectively. Insights produced and scholarly contributions from wandering include: a) an exploration of curricular alternatives to scientific literacy, notably Karen Barad’s agential literacy and Gregory Cajete’s ecologies of relationships; b) re(con)figuring visual pedagogies to engage in decolonizing science education. This theory-practice bridging pursues design of a pedagogy of relationally storying nature well positioned to account for and be accountable to Indigenous science to-come.
Preface

All research contributions herein are my own, including: the identification and design of the research program, performance of various parts of the research, as well as the analysis of the research data.

This research is conducted in support of this dissertation was approved by the UBC Behavioural Research Ethics Board (UBC BREB Numbers H13-00889 and H13-00890).

This dissertation contains content that is either published elsewhere or has been submitted for publication and is in the process of revision. In particular, Chapter 2 is a slightly modified version of a similarly titled paper Serious play: A (Socratic) dialogue on multicultural science education that is currently in revision. A large portion of Chapter 3 is accepted and forthcoming as manuscript titled Reconfiguring the optics of the critical gaze in science education (after the critique of critique): (Re)thinking “what counts” through Foucaultian prisms in the journal Cultural Studies in Science Education. The remainder of Chapter 3 is included within a manuscript titled Reconfiguring the optics of the critical gaze in science education (after the critique of critique): (Re)thinking “what counts” through Baradian diffraction which is currently in revision. Chapter 4 features elements from Positing an(other) ontology within science education: Towards different practices of ethical accountability within multicultural science education which is forthcoming in Scantlebury and Milne’s edited collection Material practice and materiality: Too long ignored in science education. Chapter 6 contains elements of Chasing excess: Putting to work what photovoice theoretically is (not) which appears in the International Journal of Qualitative Studies in Education as well as Rebraiding photovoice: Putting to work Indigenous conceptions of praxis and standpoint theory which appears in the Australian Journal of Indigenous Education. Chapter 6 also includes elements of De/signing research in education: Patchwork(ing) methodologies with theory which is currently in review and co-authored with Brooke Madden, Marie-France Bérard, Elsa Lenz Kothe, and Susan Nordstrom. In addition, Chapter 6 includes parts of Braiding designs for decolonizing research methodologies: Theory, practice, ethics which is currently submitted and co-authored by Heather McGregor, Brooke Madden, and Julia Ostertag. I have carried out all of the research associated with and authored all components of the two previous manuscripts that appear in the dissertation. Lastly, Chapter 7 draws from elements of Decolonizing school science: Pedagogically enacting agential literacy and ecologies of relationships which appears as a chapter in Taylor and Hughes’ edited collection Posthuman research practices in education.
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List of Abbreviations

IK: Indigenous knowledge
IWLN: Indigenous ways-of-living-with-nature
IS: Indigenous science
NOS: Nature of science
TEK: Traditional ecological knowledge
WMS: Western modern science
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Chapter 1: Wandering the Pathways of Science Education: Response-ability

Towards Indigenous Science To-Come

This ‘beginning,’ like all beginnings, is always already threaded through with anticipation of where it is going but will never simply reach and of a past that has yet to come. It is not merely that the future and the past are not ‘there’ and never sit still, but that the present is not simply here-now. Multiply heterogeneous iterations all: past, present, and future, not in a relation of linear unfolding, but threaded through one another in a nonlinear unfolding of spacetime-mattering, a topology that defies any suggestion of a smooth continuous manifold (Barad, 2010, p. 244)

As Barad (2010) reminds us, “the present is not simply here-now” (p. 244, emphasis mine). Rather, it is also a dis/continuous enfolding of heterogenous there-thens. This is to say that the central process of this dissertation - considering the relation between Indigenous metaphysics and classical metaphysics by way of quantum metaphysics, and the ethical, epistemological, and ontological implications for science education - has and will have already begun elsewhere and elsewhen (both past and futures to-come). Then again, both quantum and Indigenous metaphysics “caus[e] trouble for the very notion of ‘from the beginning’” (Barad, 2010, p. 245; see also Cajete, 2000). On this note and nonetheless, this inquiry must begin some-where and some-time, even though these spacetime coordinates (what are conventionally referred to as history and geography, as separate and separable; see Barad, 2010) cannot be torn asunder from their co-constitutive otherness.

Before “beginning,” the purpose of this chapter is to introduce the relationships between metaphysics, decolonizing and postcolonial approaches to science education, and deconstruction that are central to the work to come within this dissertation. Framing of relationships is done in three parts that provide orientations for the reading journey. The first provides an overview of some of the pathways explored with/in decolonizing science education: decolonizing and post-colonial science education in response to the metaphysics of modernity. The second unpacks deconstruction in relationship to decolonizing methodologies as well as decolonizing science education as a (meta-)methodological approach to (re)open the metaphysics of modernity. The third outlines the overall format of the dissertation which includes: an orientation to how a reader might go about reading the dissertation, as well as the three arcs which compose this work, and an overview of Chapters 2-7. In

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1 Within this introductory chapter, such there-thens entangled with the here-now might notably include the following SpaceTime coordinates: Calgary, Canada 2016 [Big Thinking Address at Congress]; Kalamazoo, US 1992 [first “Science Dialogues”]; diffracted through Stony Nakoda Nation (west of Calgary), Canada 1989 [Native science conference, Little Bear meets Peat and makes arrangements to meet David Bohm]; Albuquerque, US 1999 [Science dialogues continue where original funds from Fetzer institute ran out]; Ottawa, Canada 1994 [David Peat writes the introduction to the first edition of Blackfoot Physics]; Thunder Bay, Canada 2008 [I read Blackfoot Physics for the first time]; Iqaluit, Canada 2009 [I am delivering my first cross-cultural science education research project].
this chapter, as in those that follow, I initiate the work with a positional vignette that give glimpses of the curiosities and questions that motivate and guide my explorations and give shape to the inquiries to come.

1.1 “Blackfoot Metaphysics is Waiting in the Wings”: My Relation to Indigenous Metaphysics, the Metaphysics of Modernity, and Science Education

Because we need to “begin” some-where and some-time, let’s “begin” in Calgary, Alberta on June 1st, 2016. Blackfoot scholar Leroy Little Bear is giving a Big Thinking address at the annual Congress of the Humanities and Social Sciences. The title of his talk: “Blackfoot Metaphysics is Waiting in the Wings.” Playing off the title as he walks onto the main stage, Little Bear jokes “[waiting in the wings] just like I was a few minutes ago”. This calls to mind(-body-heart-spirit) the importance of making connections through humour (see also Little Bear, 2000). Leroy Little Bear invites those in the crowded auditorium to (re)consider what Blackfoot and other differentially articulated Indigenous metaphysics (i.e., the co-constitutive space of axiology, epistemology, ontology, ethics, and cosmology) continue to offer: ways-of-knowing-in-being premised on ethics, relationality, process, flux, and renewal centering a sense of place. Furthermore, he articulates a need to consider Indigenous metaphysics in response to the metaphysics that are already and often in operation within educational spaces: “What are the metaphysics of our schools? Where are those metaphysics taking us?” Articulating a metaphysics of modernity as taken-for-granted, unquestioned, and unstated, Little Bear subtly shifts the statement that metaphysics is (i.e., singular and a priori) to one wherein metaphysics are and are in relation (i.e., plural and entangled in the world’s ongoing becoming). Furthermore, he motions that the metaphysics of modernity continues to provide some comforts (e.g., material goods), “but at what price? Is our metaphysics making us better? Happier?” he asks. In referring to this metaphysics as ours, Little Bear signals that metaphysics is not strictly a binary either/or affair, as in Indigenous or Western. Rather, metaphysics is always both/and. In other words, metaphysics are neither separate nor separable, but rather always co-constituted and co-constitutive. In turn, responsibility for the metaphysics of modernity is also shared. Making his concluding remarks, Little Bear suggested that it is time to move Blackfoot and other Indigenous metaphysics from the wings to the main stage where their contributions might significantly come to bear in generative ways.

During this address, Little Bear only hinted at the ways in which the knowledge-practices of Indigenous metaphysics come to be positioned in the wings where they have been waiting for a long
time. He signaled dialogues that began over 20 years ago² between Indigenous Elders and scholars (e.g., Leroy Little Bear, Chickasaw and Cheyenne scholar Sakej Youngblood Henderson) and Western scientists and linguists (e.g., quantum physicists David Peat and David Bohm). During these dialogues, they met “to discuss the underlying principles of the cosmos, not from an adversarial point of view, but from one of mutual respect and deep listening” (Parry, 2008, p. 37). The purpose of Science Dialogues was not to work towards knowledge, but rather understanding (see Little Bear, 1994; Parry, 2008; Peat, 2002, 2007). This certainly was not the first time, nor would it be the last that such an initiative towards cross-cultural understanding would take place. Yet, despite such efforts, Indigenous metaphysics still waits in the wings.

When I began graduate studies in decolonizing science education in 2008, the very first book I read was David Peat’s (2002) Blackfoot Physics (the first edition, entitled Lighting the Seventh Fire, drew from and was released two years following the 1992 Science Dialogues). While I was on the lookout for Indigenous science, Peat (2002) reminds that Indigenous metaphysics and Indigenous science are differential articulations of one another that cannot be separated (see also Cajete, 1994, 2000):

As a science, [Indigenous science] is a disciplined approach to understanding and knowing, or rather, to the processes of coming to understanding and knowing. It has supporting metaphysics about the nature of reality, deals in systems of relationship, is concerned with the energies and processes of the universe, and provides a coherent scheme and basis for action. On the other hand, it is not possible to separate Indigenous science from other areas of life such as ethics, spirituality, metaphysics, social order, ceremony, and a variety of other aspects of daily existence. This it can never be a “branch” or a “department” of knowledge, but rather remains inseperable from the cohesive whole, from a way of being and of coming-to-know (p. 241, emphasis mine).

Blackfoot Physics was a powerful early read for me as it discusses the “points of resonance” between Indigenous metaphysics and quantum physics that emerged from the Science Dialogues. Holding the complexity of difference without subsuming it into sameness, Blackfoot Physics explored these two systems that diversely articulate flux and relationality concurrently, providing me with a hopeful potentiality for science education to be constituted and enacted otherwise. Notably, the possibility for respectful, relevant, and responsive science education whose pedagogical potency is enriched from cross-cultural diversity resonated with my own professional experiences of working as an informal physics and science educator in First Nations, Métis, and Inuit communities across Canada. I had witnessed and contributed to science education as plurality; science education shaped by cross-

² These dialogues began in 1992 (see Little Bear, 1994; Parry, 2008; Peat, 2002, 2007) but have seemingly ceased in the last few years.
cultural understandings through similar, yet different, practices including language; and science education that draws strength from cultural and placed locations, instead of treating difference as an individual problem located with the one who diverges from the norm. In my experience there was no lack of respectful, reciprocal, and relational models for cross-cultural science education drawing from Indigenous traditions (e.g., Aikenhead, 1997, 2006b; Cajete, 1999). Yet, despite science being a fruitful location for cross-cultural points of resonance, to my surprise Indigenous metaphysics was still waiting in the wings when it came to most science education spaces. Blackfoot Physics illuminated the ways in which Indigenous science was yet-to-come and productive locations to bring about that potentiality.

The following summer, I would attempt to create space for the potentiality of Indigenous metaphysics within and as science education research. I returned to Iqaluit, Nunavut in the Canadian arctic where I had previously delivered informal cross-cultural science education. My efforts took the shape of a curricular project in which Indigenous (i.e., Inuit) and non-Indigenous youth explored differential cultural constructions of local enactments of science through videography. Through this project, the youth learned and refined movie-making skills and practices in order to explore, define, and document the diverse ways-of-knowing-nature that were enacted in their community (e.g., Western modern science, Inuit Qaujimajatuqangit [i.e., Inuit traditional knowledge]). This participant-directed videography took various shapes, notably documentary-style interviews with diversely positioned community members (e.g., traditional knowledge holders, health practitioners, environmental scientists), alongside their own short movies that were a form of digital storytelling, one of which is introduced below.

Two curiosities emerged through this educational research. The first was that the co-constitutive relationship between Indigenous metaphysics and the metaphysics Western modernity was one that was complex, uneven, and unequal. In short, the pedagogical ways that I laboured towards privileging Indigenous metaphysics were exceeded and differentially constituted by the metaphysics of modernity my approach endeavored to work against. Through the process of attempting to make space for pluralism, pedagogical slippage occurred. Plugging Indigenous metaphysics into an educational framework organized by a classical Western metaphysics resulted in excess that was far too often sutured over, subsumed, and/or sublated by an approach to understanding and being with nature that could not account for the former (see Carter, 2004, 2005, 2010; Sammel, 2009; see also Ahenakew, Andreotti, Cooper, & Hireme, 2014). This is directly
related to the second curiosity.

The dialectic negation of Indigenous metaphysics produced a partial blindness to the ways in which it always already manifests itself despite an uneven metaphysical relation. In short, the stories that the youth told through their digital storytelling practices (e.g., of Muhaha, the aptly named traditional Inuit bedtime-story monster who chases after children to tickle them to death with his long claws) were not simply stories about place (i.e., having an Indigenous “sense of place”) but were told with place (i.e., having and being had by a “sense of place”). In the videos, place makes itself intelligible through the beings that come to constitute the ecology of relationships that make the eastern arctic a beautiful, yet dangerous place if not respected on its own terms (see Higgins, 2014a). The stories were never the students’ (and the humans they worked with) alone: the natural world always makes itself intelligible and participates in the construction of knowledge about itself (see Apffel-Marglin, 2011; Bang & Marin, 2015; Cajete, 1994, 2000).

Now seven years later, at the (space)time of writing this dissertation (i.e., Vancouver, Canada 2016), Indigenous metaphysics’ status of “waiting in the wings”, of not yet having (fully) arrived, comes as less of a surprise (for reasons made apparent through the dissertation journey). As McKinley and Stewart (2012) state, “the aspiration of defining and understanding IK [Indigenous knowledges] (in order to place it in the science curriculum) can be likened to chasing the pot of gold

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While both curiosities are significant drivers of my work of late (e.g., Higgins, 2016a) and are both important, this dissertation focuses more firmly on the former (i.e., dialect negation of Indigenous metaphysics by Western metaphysics) than the latter (i.e., characteristics of Indigenous metaphysics). This places me firmly in a conversational relationship with the field of science education so that it might be (re)opened to the possibility of Indigenous metaphysics (to-come).

The addressee to whom the account of this work is given is of no small significance, both in terms of what can and cannot be enunciated, as well as its possible possibilities and problematics. As Butler (2005) states,

*There can be no account of myself that does not, to some extent conform to the norms that govern the humanly recognizable, or that negotiate these terms in some ways, with various risks following from that negotiation. … No account takes place outside the structure of address, even if the addressee remains implicit and unnamed, anonymous and unspecified. The address establishes the account as an account.* (p. 36)

Whereas I generally address my work to others already and actively engaged in processes of decolonizing education, the intended addressee in this work is, more generally, those situated in the field of science education whose consideration of decolonization and/or post-coloniality is to-come (as an unactualized potentiality and a tout-autre [wholly-other] whose voice has gone unheard because it cannot yet be heard; see Spivak, 1993/2009). This entails that, as a means of (ethically) accounting for and being accountable to this implicit addressee, I often draw from epistemic resources that may be intelligible as such (e.g., canonical science education literature and well-recognizable scholars) in my efforts to work at the limits of intelligibility (i.e., to (re)open science education to the possibility of Indigenous science to-come).

However, as Butler (2005) states, the productive necessity of giving an account over to an addressee is not without risk. Here, the most significant risks posed by this are that, first, there risks a too-easy and representational(ist) reading which produces a perception that Indigenous science wholly yet-to-come (see next footnote) or that this is a space that has not been and continues to be laboured by Indigenous and ally scholars. Secondly, working within this space of un/intelligibility nonetheless defers and differs intended meanings of Indigenous science; but how does one articulate the unarticulable within the frames that render them such? For example, an Indigenous “sense of place” (Cajete, 1994) and other lived concepts are differentially articulable and intelligible when accounting for and being accountable to this double(d) relation to science education and Indigenous science.
at the end of the rainbow, which remains permanently out of reach” (p. 551). Despite its “to-come” status, the potential of Indigenous metaphysics (and its differential articulation as Indigenous science) within and beyond cross-cultural science remains a central motivation that continues to drive my research agenda that is grounded in an ethical commitment towards a futurity in which Indigenous metaphysics is no longer “waiting in the wings.”

Barad (2010) suggests, “we inherit the future, not just the past” (p. 257). In considering the future, we not only inherit the future (avenir) that is the most possible possibility; one that prolongs and replicates the present condition, albeit differently, by restituting a foreclosed past that has not yet to happen (again). We also inherit futures that are yet-to-come (à-venir); those unexpected arrivals that produce a (re)opening of difference whereby possibilities and consequences are not (fully) knowable. However, “there is no inheritance without a call to responsibility” (Derrida, 1994, p. 261); a responsibility that is not only an epistemological and ontological accounting for but also an ethical accountability towards that which is yet-to-come (see also Kuokkannen, 2007; Spivak, 1994). The Other-ness that has yet-to-arrive (e.g., a future to-come where Indigenous metaphysics is no longer “waiting in the wings” of science education⁴), whose arrival cannot be anticipated, is entangled in what Barad (2010) refers to as “relations of obligation”:

Othering, the constitution of an ‘Other,’ entails an indebtedness to the ‘Other,’ who is irreducibly and materially bound to, threaded through, the ‘self’ – a diffraction/dispersion of identity. ‘Otherness’ is an entangled relation of difference (différance). Ethicality entails noncoincidence with oneself. (p. 265)

As the future (avenir) and the to-come (à-venir) are not one and the same, the present of science education is irreducibly bound to and ethically indebted to Indigenous science to-come. This potentiality that has yet-to-come, whose arrival is unforeseeable, invites “the continual reopening and unsettling of what might yet be, of what was, and what comes to be” (Barad, 2010, p. 264, emphasis in original).

In order to engage in the work of un-settling (i.e., what I have come to understand and will present as deconstructing and decolonizing) what might yet be, what was, and what will come to be science education, the central question that guides the research presented within this dissertation is: How is Indigenous science to-come with/in the context of science education? The central question is understood and explored in this dissertation through three guiding inflections that are inseparably entangled. First, to-come signals that Indigenous metaphysics, in the context of science education,

⁴ This is not to state that Indigenous science is flatly yet-to-come as it is a practice of living with Nature that Indigenous peoples have been enacting with/in place since time immemorial (see Cajete, 1994, 2000). Rather, it is to state that it is still (partially) “waiting in the wings” of science education (see McKinley, 2007; McKinley & Stewart, 2012).
has not yet (wholly) arrived. This precipitates the questions: *How is it that Indigenous science is still to-come? How do the structures of science education – the assumptions, terms, categories, practices, and beliefs – contribute to exclusion of Indigenous science, as well as inclusion that disciplines, differs from, and defers Indigenous science to-come?* Secondly, to-come signals ethical indebtedness; this invites the question *How might the structure, culture, and discipline of science education be (re)opened and re(configured to receive Indigenous science to-come, on its own terms, and in ethical relation?* Thirdly, to-come entails a responsibility for and towards that which is to-come. Yet, modes, practices, and enactments of responsibility cannot be prescribed when that which is to-come is never (fully) knowable and distorted by the current frames of science education. Stated otherwise, responsibility requires the occasion and ability to respond. Accordingly, I wonder: *What types of practices*<sup>5</sup> *might allow for and nurture the possibility of Indigenous science to-come?* This final query recognizes that potentiality need not require actualization for it to be worthy of consideration.

To situate the engagement with the central questions and its different inflections, the remainder of the introductory chapter provides three orientations to guide the reader through the dissertation. Recall that the first of three introduces decolonizing and post-colonial approaches to science education, the disciplinary spaces within which I situate this work. However, as the metaphysics of modernity is often entangled with/in enactments of WMS and science education, (re)producing Indigenous science as to-come, this relation is also explored.

### 1.2 First Orientation: An Introduction to Decolonizing and Postcolonial Science Education and their Relationships to Metaphysics

As [Derrida] develops the notion of the joyful [i.e., play-full] yet laborious strategy of rewriting the old language – a language, incidentally, we must know well – Derrida mentions the "cloture" of metaphysics. We must know that we are within the "cloture" of metaphysics, even as we attempt to undo it. It would be an historicist mistake to represent this "closure" of metaphysics as simply the temporal finishing-point of metaphysics. It is also the metaphysical desire to make the end coincide with the means, create an enclosure, make the definition coincide with the defined, the "father" with

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<sup>5</sup> Practice, as enacted and discussed herein, is not strictly understood in the conventional sense (e.g., institutional teaching and learning). Rather, the practice prominently articulated and employed herein is that of decolonizing and post-colonial science education scholarship-as-practice. This is in line with decolonizing and post-colonial science education scholars who articulate that theory too is a practice (Carter, 2005; McKinley & Aikenhead, 2005), as well as recent calls in science education there is too much focus on empiricism (and in turn too much data) and not enough scholarship-as-practice (see Carter, 2010). Furthermore, it is also in line with conceptions of decolonizing and educational research which advocate for attentiveness to the practices one is already engaged in, as well as the norms through which attention is deferred elsewhere and differed: paying attention to the process without relegating its justification to the product (see Higgins, Madden, Bérard, Lenz Kothe, & Nordstrom, in press; Lenz-Taguchi, 2010; McGregor, Madden, Higgins, & Ostertag, submitted; Smith, Maxwell, Puke, & Temara, 2016; St. Pierre, 2011a, 2011b). Nonetheless, Chapters 6 and 7 explore the development and delivery of a school-based pedagogical practice.
I begin this section by asking: what does metaphysics (i.e., the co-constitutive space of epistemology, ontology, ethics, among others) have to do with science education and Indigenous science to-come? Recall, from the previous section, that Indigenous science is always already an articulation of Indigenous metaphysics and an inseparable part of the whole (see Cajete, 1994, 2000; Little Bear, 2016; Peat, 2002). However, what of Indigenous metaphysics within the Western modern science (WMS) which largely comes to inform most of science education’s school-based curricula? As Derrida (1976) offers, we are always already within the clôture (i.e., enclosure) of metaphysics: there is no outside of metaphysics (see also Spivak, 1976). Also, as stated earlier, there is no outside of the metaphysics of modernity (see also Apffel-Marglin, 2011; Carter, 2010; Little Bear, 2016; Spivak, 1976, 1993/2009, 1994, 1999).

WMS and science education too must also be within, and have, a metaphysics. Sciences, in all shapes and forms, are premised upon the ways in which Nature’s enactments (i.e., ontology) are understood through and in relation to Culture (i.e., epistemology) (see Barad, 2000; Cajete, 2000; Kirby, 2011; Latour, 1993). However, as Little Bear (2016) enunciated in his keynote address, the metaphysical relation between Nature and Culture enacted by Western modernity that informs and produces WMS is often one that assumed, presumed, and/or taken-for-granted. Thus, in response to Little Bear’s questions, “What are the metaphysics of our schools? Where are those metaphysics taking us?” and I would add, What are the metaphysics of science education?, I offer that WMS and by extension science education are articulated as transcending metaphysics (Barad, 2000, 2007; Cajete, 1994, 2000). This (self-)perceived metaphysical exclusion becomes a criticism that is levied against other ways-of-knowing-Nature (e.g., Cobern & Loving, 2001), becoming one of the ways in which Indigenous science is (yet-)to-come (McKinley, 2007). Answering (and being answer-able as form of responsibility; see Spivak, 1994) to the metaphysics of science education then becomes a question of (mis)reading science education for its subtle and lingering (neo-)colonial referents and enactments (Carter, 2004, 2005; McKinley & Aikenhead, 2005): the process of “joyful [i.e., playful] yet laborious strategy of rewriting the old language” (Spivak, 1976, p. xx) that is deconstruction. (Re)opening science education to Indigenous science-to-come labours the structure of education between what it is, is not, and could be(come), particularly in instances when meanings
(and matter) are sedimented and stratified (e.g., through knowledge-practices such as science as metaphysically transcendent).

Regarding the metaphysics of science education, Derrida (1976) nonetheless offers that the metaphysics of modernity are both the process and product of clôture: at once being an enclosure and a closing. This double(d) normative process can never be wholly separated from “the metaphysical desire to make the end coincide with the means” (Spivak, 1976, p. xx). In other words, the closing is naturalized, rendering the process an absent presence whose partial erasure (but irreducible presence) gives the appearance of stable, unitary, separate, and separable epistemological and ontological units (see also Appfel-Marglin, 2011; Bang & Marin, 2015; Barad, 2007; Cajete, 1994, 2000; Latour, 1993). However, how the metaphysics of modernity are always already entangled within science education, how this entanglement is produced, as well as what it produces, and what is produceable with/in are undertakings engaged within this dissertation. If we are to (re)open science education to Indigenous science to-come, “it is from within this language that we must attempt an ‘opening’” (Spivak, 1976, p. xx), we must do so with/in science education, “a language, incidentally, we must know well” (p. xx). Thus, in the next section of this introduction onto science education, Indigenous science to-come, and metaphysics, I outline some of the features of science education and its relationship to Indigenous science.

1.2.1 Understanding school science and its relation to Indigenous science to-come.

Generally speaking, within science education, “the conventional goal” is one “of thinking, behaving, and believing like a scientist” (Aikenhead & Elliot, 2010, p. 324). Currently, through the two predominant methods of teaching and learning science, this entails: coming to know what scientists know (i.e., cognitivism, intra-personal learning, scientific knowledge as representation of nature) and/or enculturation into how scientists come-to-know (i.e., socio-constructivism, inter-personal learning, scientific knowledge as representation of culture) (Aikenhead, 2006a; Erickson, 2001). Untroubled, both approaches collude and coalesce around the construction and reification of the subject position of “Scientist.” It has been argued that this subject position is emblematic of the masculine, Eurocentric, and anthropocentric subject of Western modernity through modes that enact and uphold its metaphysics (e.g., representationalism, universalism, nature/culture divide) (see Barad, 2000, 2007). This (re)produces science as a modern(ist) practice through which nature is knowable and representable (i.e., quantifiable, generalizable, and predictable; see Aikenhead & Michell, 2011; Aikenhead & Ogawa, 2007), and in which neither the culture of science nor the
agency of nature can be (wholly) accounted for or be held accountable. Furthermore, this type of scientific literacy and its entangled culture of ‘school science’ potentially produce experiences of cultural assimilation and acculturation rather than enculturation for the vast majority of students.

In other words, rather than a harmonious interfacing of cultures (i.e., enculturation), encounters of school science are more likely to house potential for dialectical negation that is either actualized (i.e., assimilation) or remains un-actualized through students’ complex and complicated curricular navigation (i.e., acculturation). Such dialectic negation occurs at the level of the individual, as well as the system. In reviewing literature on science education in diverse school settings, Aikenhead and Elliot (2010) state that “most students (about 90%) tend to experience school science (Grades 6–12) as a foreign culture to varying degrees, but their teachers do not treat it that way” (p. 323; see also McKinley, 2000, 2007; McKinley & Stewart, 2012). For students whose daily lived experiences continue to be negatively impacted by Eurocentrism (re)produced within (and beyond) science education, learning within the cultural practice of ‘school science’ largely continues to be a form of epistemic violence. As such, assimilation is overwhelmingly identified as a common barrier to engagement (Aikenhead, 2006b; Barnhardt & Kawagley, 2005; Canadian Council on Learning, 2007; McKinley, 2000, 2007).

There are various ways in which this systemic problematic manifests at the level of individual students and groups. For Indigenous, diasporic, and other post-colonial students, these include, but are not limited to: a) under-representation within science and technology occupations, b) under-representation within formal education and training that paves pathways to such occupations, c) gaps in achievement on standardized international assessment such as the Programme for International Student Assessment, and d) lower rates of graduation (Barnhardt & Kawagley, 2005; McKinley, 2000, 2007).

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6 Potential is significant to highlight here. As Aikenhead (2006a) points out, “students and many teachers react to being placed in the political position of having to play school games” (p. 28). In turn, they often creatively subvert this positioning by playing what is called “Fatima’s game” in science education “to make it appear as if significant science learning has occurred even though it has not” (p. 28).

7 See Aikenhead and Elliot (2010) for the various qualitative and quantitative science education studies that come to inform this figure.

8 In short, Eurocentrism is a discursive force which (re)centers Western modern(ist) culture, people, places, and histories as the normative standard against which other ways-of-knowing are judged, usually as lesser and deficient (see Battiste, 2005, 2013b). It is not only the “colonizer’s model of the world” (Blaut, 1993, p. 10), but also a colonizing model of the world. Operating through diffusionism, a forced spread of culture, it erases or assimilates non-Eurocentric knowledge systems establishing “the dominant group’s knowledge, experience, culture and knowledge as the universal norm” (Battiste, 2005, p. 124).

9 I use “post-colonial student” here as a general category and concept to include other-than-Indigenous and other-than-diasporic students who might also might be negatively impacted by ongoing (neo-)colonialism and/or who are implicated and involved in the productive friction signaled by the “post” (i.e., an ever partial but nonetheless productive attempt to move beyond (neo-)coloniality).
Canadian Council on Learning, 2007; MacIvor, 1995; McKinley, 2007). For Indigenous, diasporic, and post-colonial students who succeed in spaces of WMS despite the odds that are stacked against them, it is often at a cost: learning science is often at the expense of one’s cultural being and belonging, becoming otherwise in the process (see Cajete, 2000; McKinley, 2005, 2007). Furthermore, as local Indigenous ways of coming-to-knowing the natural world continue to be underrepresented, misrepresented, misunderstood, and undervalued, WMS tends to be overrepresented and misrepresented (Aikenhead, 1997, 2006b; Aikenhead & Michell, 2011; Aikenhead & Ogawa, 2007). As a result, many students come away from science education with an understanding of WMS that is shaped by myth (e.g., science as culturally neutral, unbiased, and thus ethical), alongside under-appreciation of what other ways-of-knowing-nature might have to offer.

This not only has an impact upon students, but also their teachers: “stereotypical views of [I]ndigenous students [and their knowledge-practices] have led to assumptions of teaching and learning for them” (p. 214, emphasis mine). In a study with science teachers of Indigenous students, Aikenhead and Huntley (1999) documented four ways that deficit thinking manifests:

1. Teachers generally viewed Western science as course content or as a way of exploring nature, not as a foreign culture as experienced by many of their students; 2. Aboriginal knowledge was respected by science teachers, but only a token amount was added onto, but not integrated with, school science; 3. Teachers thought that the act of learning science was unrelated to their students’ [Indigenous] worldviews; 4. Students’ disinterest in pursuing science careers was either unexplainable by the interviewees or was blamed on student deficits. Few teachers blamed their curriculum and teaching. (pp. 162, 164)

If science education is to be (re)opened to Indigenous science to-come, it is important to recall that the ethical imperative of education is “a responsibility to the Other (as answerability or accountability) and not for the Other (as the burden of the fittest)” (Andreotti, 2007, p. 74, emphasis mine), as well as recognition of the ongoing (re)construction, enactment, and productions that result from such positioning (see also Kuokannen, 2007, 2010; Spivak, 1994).

The ways in which Indigenous ways-of-living-with-nature (IWLN) come to be under- and misrepresented signals how dialectic negation plays out at systemic, cultural, and discursive levels. The very topic of IWLN in science education is itself subsumed within wider concepts such as multiculturalism and equity that fail to wholly account for the complexities of Indigenous-Western relationships (Carter, 2004, 2010; McKinley & Stewart, 2012). Furthermore, the term traditional ecological knowledge (TEK) that is regularly employed potentially (re)centers a Western modern(ist) notion of knowledge as a discrete unit that exists outside of and beyond the knower and its ecology of relationships (Aikenhead & Ogawa, 2007; Aikenhead & Michell, 2011; McKinley,
2007). However, McKinley and Aikenhead (2005) state that while these concepts and conceptual locations have been problematic, they nonetheless provide productive locations to critically inhabit science education and gain leverage (see also McKinley & Stewart, 2012). Whether Indigenous science should be included or not within science education, as well as how, where, and when, has become:

…one of the largest (in terms of literature) debates in the field of culture and science education… [which has centered around] the nature of knowledge…. The relevance of this literature to schools is that a universalist understanding of science informs the assumptions implicit in school curricula about the nature of science and how science should be taught. (McKinley, 2007, p. 206)

As what is called the multicultural science education debate is of central relevance to the ways in which Indigenous science is to-come, it is revisited and explored in further depth in Chapter 2.

“Universality” (i.e., transcendental knowledge) is “achieved” when metaphysics of modernity come to mark IWLN, TEK, and WMS through systems of clôture (e.g., as either strictly similar or different), as well as when WMS reasserts itself as the (“neutral”) norm and standard against which other knowledge systems are to be judged through Eurocentrism (see Carter, 2004; Lewis & Aikenhead, 2000). On the topic of sameness and difference, McKinley (2007) states that the relationship between IWLN and WMS can be generalized into four categories: a) where Indigenous science can be explained within WMS; b) where Indigenous science could be explained through WMS, but the explanation has yet to be developed; c) where there is a link between Indigenous science and WMS’s knowledge claims, albeit through different knowledge principles and practices; d) where WMS cannot accept aspects of Indigenous science (e.g., spirituality, animism). The extent to which if and how Indigenous science is to be included within school science curriculum depends highly upon the type of Indigenous knowledge (IK) being brought in, as well as science education’s ability to ethically respond to difference (see also Kuokanen, 2007; Marker, 2006); some forms of Indigenous science are more to-come than others. As the relations of power between IWLN, TEK, and WMS are uneven and unequal, it is often the case that “those opposing the inclusion [of IK] argue that there is no place for IK unless it has been subsumed into the body of knowledge referred to as WMS, that is, unless it is made the same as WMS, in which the status quo continues” (McKinley, 2007, p. 208). Alternately, some who uphold the universality of WMS (e.g., Cobern & Loving, 2001; El-Hani & de Ferreira Bandeira, 2008) argue that the inclusion of Indigenous science is a non-issue so long as it is neither called science nor included within the science classroom (but rather as a separate subject, like art, literature, or history). However, such
“inclusion” fails to redress the dialectic negation of Indigenous science marked by sublation, susbsumation, or suturation, as well as masks the colonial relations of power that produce these moves (see McKinley, 2000, 2007). As mentioned early within this chapter, dialogue between Indigenous science and WMS is in a perpetual state of im/possibility as they are not and never will be (fully) commensurate; Indigenous science will always be to-come but the ethical responsibility is ever-present and irreducible.

1.2.2 Decolonizing and post-colonial responses in science education.

There are growing bodies of work within science education that address Western modernity’s Eurocentric legacies that are often referred to as: decolonizing science education (e.g. Aikenhead, 2006c; Aikenhead & Elliot, 2010; Belczewski, 2009; Chinn, 2007; Higgins, 2014a) and post-colonial science education (e.g., Carter, 2004, 2005, 2006, 2010; McKinley, 2000, 2007; McKinley & Aikenhead, 2005; McKinley & Stewart, 2012). Battiste (2013a) describes decolonizing education as is a “two-prong process”. It entails deconstruction of (neo-)colonial structures and strategies, and reconstruction that centres and takes seriously Indigenous, diasporic, and other post-colonial ways-of-knowing and ways-of-being towards reshaping the place-based processes and priorities of education and educational research (see also Donald, 2011). Similarly, post-colonial approaches to

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10 Decolonizing, Indigenous, and post-colonial scholarship share many similar facets. However, as McKinley (2007) states, 
Postcolonialism is controversial among many groups... For many [I]ndigenous researchers [and allies] the term signals that the European imperial project, and the appropriation of the ‘Other’ as a form of knowledge, has been assigned to an historical past... This understanding is always present in postcolonialism... [However,] postcolonialism can be used to mean “beyond;” instead of arguing lineal progression of before and after a point in history, another dimension is added with this alternative meaning... “beyond” suggests that boundaries or borders have become blurred. (p. 201, emphasis in original)

Most famously, Linda Tuhiwai Smith’s (1999/2012) rejection of post-colonialism (as and through its first meaning of “after” colonization) is most cited today, even if she has since revisited and revised her earlier statement to consider the second interpretation to be deeply productive in practice (see Smith, 2005).

11 With respect to coloniality, neo-coloniality, and their relationship, Spivak (1999) states the following:
Let us learn to discriminate the terms colonialism – in the European formation stretching from the mid-eighteenth to the mid-twentieth centuries – neocolonialism – dominant economic, political, and culturalist maneuvers emerging in our century after the uneven dissolution of the territorial empires – and postcolonialism – the contemporary global condition, since the first term is supposed to have passed or be passing into the second. (p. 172, emphasis in original)

By highlighting that the contemporary global post-colonial condition is supposed to have passed from colonialism to neo-colonialism, Spivak brings attention to the ways in which coloniality and neo-coloniality are bound by a relationship of constitutive exclusion. In other words, the ongoing project of territorial imperialism is never absent but always already present, even if it is increasingly tied to a project of economic imperialism.

12 Battiste’s (2013a, 2013b) framework is overarching. An implicit message throughout her scholarship is that the work of decolonizing education is multi-faceted, multi-sited, divergent, and pluralistic in nature. In turn, decolonizing education resists the notion that there is a way of doing it – that difference and diversity in positionalities, contexts, approaches, and inclinations are strengths rather than weaknesses. This is particularly significant (in general and within this dissertation) as the metaphysics of modernity, as well as its Eurocentric and Cartesian modes are not uniform, but rather are differentially articulated across diverse locations.
science education seek to (re)open (neo-)colonial structures strategies in order to ethically respond to the Other-ness of Indigeneity. As both draw from diverging theoretical lineages and enactments of educational practice (e.g., critical pedagogy and post-structuralism respectively), there are productive points of resonance and tension between the two. Of the latter, and of particular relevance to this dissertation, are: a) the centrality of land as beyond human cultural understandings of it, and b) whether ethics is a possible possibility or not. Herein, regarding the first statement, I align with decolonizing theories who suggest that post-colonial theories’ focus on cultural hybridity, flow, and porosity do not strongly enough consider the ways in which coloniality operates and circulates beyond an anthropocentric (inter-)textuality. The critique is levied to bring attention to the ways in which (neo-)coloniality comes to problematically shape not only human cultural relations, but also those of other-than-humans, and more-than-humans who, together, come to collectively constitute the ecology of relationships that is signified by an Indigenous concept of place (Donald, 2011; Grande, 2004, 2008; Smith, 1999/2012). With respect to the latter statement, I align herein with post-colonial notions of ethics as im/possibility to push forth my own decolonizing scholarship; the discursive practices of decolonizing approaches can (but do not always) come to mask colonizing tendencies (see Carter, 2004, 2010; Subreenduth, 2006; Rhee & Subreenduth, 2006; Smith, 2005; Smith et al., 2016, Spivak, 1993/2009). Nonetheless, ethical im/possibility need not be paralyzing; Spivak (1988a, 1993/2009, 1994) reminds of the importance of persistent critical and complicit enactments that work towards “transforming the conditions of impossibility into possibility” (Spivak, 1988b, p. 201), even if/as they are never achieved.

Within science education, this call has been primarily taken up by extending the openings produced through treating both science (e.g., Haraway, 1989; Latour, 1993; Traweek, 1992; see also Shapin & Schaffer, 1985) and science education (e.g., Nadeau & Désautels, 1984; O’Loughlin, 1992; Pomeroy, 1994) as problematic cultural spaces to be examined through sociological, anthropological, and cultural studies approaches. In particular, a two-pronged approach to decolonizing science education focuses primarily on addressing the ways in which Eurocentrism (re)produces science education as a space of cognitive and cultural imperialism (Aikenhead, 2001, 2006c).

13 For Spivak, education is a post-colonial site that discursively produces the very conditions of ethical im/possibility: education places teachers with (unlike) others while institutionally framing learning as knowing what is best for the other (see Andreotti, 2007; Spivak, 1993/2009).
14 In her ethnography of school-based science education, Deborah Pomeroy (1994) came to refer to the “standard account” curriculum of WMS as one of White Male Science.
15 Of course, “decolonizing school science begins at the stage of ‘acceptance’” (Aikenhead, 2006c, p. 393, emphasis in original): an acceptance of IWLN and that decolonizing school science is a goal that is worthwhile and important.
2006c; McKinley, 2000, 2007; Sammel, 2009) in order to make space for learning that is epistemologically diverse and pedagogically pluralistic (i.e., which recognizes that there are diverse pathways to learning about and with Nature; Aikenhead, 2006a, Barnhardt & Kawagley, 2005, 2008; McKinley, 2007; Sammel, 2009). In Canada, there have been some successes in this area. For example, there are increasingly more policy-mandated curriculums that include Indigenous perspectives on science (e.g., British Columbia Ministry of Education’s 2005 Science K to 7 and 2008 Science and Technology 11)\(^\text{16}\), general frameworks for school-based integration in place (e.g., Manitoba Education and Youth’s 2003 Integrating Aboriginal Perspectives into Curricula), as well an overall commitment from Dean’s of Faculties of Education to prepare teachers accordingly (Association of Canadian Deans of Canada, 2010).

However, given the capillary pervasiveness of Eurocentrism and its co-constitutive mechanisms (e.g., (neo-)colonialism), decolonizing science education is not simply a process of desiring it to be decolonized. Rather, it is (over-)written in a contradictory, conflicted, and contingent space in which the very processes and practices that explicitly seek to dismantle colonial logics often implicitly uphold and reinforce that which they seek to challenge (Carter, 2004, 2005, 2010; Higgins, 2014a; McKinley, 2000; McKinley & Stewart, 2012; Sammel, 2009). On this, Carter (2004) states:

> The inclusion of Other’s science has the potential to trouble the categories of Western science, but the processes of cultural representation and translation [i.e., differing and deferring Indigenous science] ensure Western science remains authoritative in most settings. These processes simultaneously work to separate, domesticate, and subsume, regulating the boundaries and preserving the integrity of Western science and science education. Hence, the inclusion of the Other’s science in school curricula risks an empty form of pluralism implicated… in restorationist agendas to reassert Western cultural control. (p. 832)

In other words, there needs to be a constant vigilance and (re)evaluation of decolonizing goals and processes, as they are always in co-constitutive relation with (neo-)coloniality. As these discussions have primarily and almost exclusively focused on (a particular) epistemological grounds or locations (see Cobern & Loving, 2008; van Eijck & Roth, 2007), one problematic production is the lack of attention to ontology in science education.

On the topic of considering ontology within science education, Sammel (2009) states that “given the pervasiveness of assimilationism in Western science education” (p. 653), to only address the colonial episteme leaves the systemic strategies and structures that “push for assimilation of

\(^{16}\) However, integration of Indigenous perspectives does not always entail or require “acceptance” (see Chapter 2). Furthermore, even an intent to accept Indigenous science is not necessarily unproblematic.
students into Western science ontology” (p. 653) to continue functioning implicitly (see also Carter, 2004, 2005). This is to say that to treat science education uniquely as a culture potentially masks the ways in which Culture’s Other (i.e., Nature) is implicated with/in these processes (see Barad, 2000, 2007; Latour, 1993). Again, this begets the question, What are the ways in which the absent presence of the metaphysics of modernity operate in science education? (e.g., representationalism, Nature/Culture binary; see Apffel-Marglin, 2011; Carter, 2004). While there is space for diverse ways-of-knowing through a cultural critique, Sammel (2009) invites us to consider how science pedagogies and curriculums often “include the mandate of improving scientific literacy and then proceed to define it, or refer to it by way of usual contemporary science education definition” (p. 653). This practice of scientific-literacy-as-usual positions diverse ways-of-knowing-nature that are not WMS as but different, and often lesser, ways to attain the same goal of knowing nature with/in the ontology of Western modernity (Carter, 2004, 2005; see also Latour, 199317).18 The underlying and problematic message is that ontology is a singular affair (Barad, 2007).

Cartesianism, the classical Western ontological process through which meaning and matter are individuated through separation from that which co-constitutes them (e.g. mind/body, nature/culture; Apffel-Marglin, 2011; Barad, 2007; Cajete, 2006), often becomes the (only) ontology onto which diverse ways-of-knowing differentially map. This tends to differentially re-center WMS as the meter stick against which all ways-of-knowing and ways-of-being are measured. When Cartesianism is the (only) ontology, it only makes sense that the epistemology of WMS that co-constitutes Cartesianism is best suited to work with/in this ontological configuration (see Cobern & Loving, 2008). However, to forget that it is an ontology rather than “ontology” (read: singular) when doing cross-cultural and comparative work is to position other-than-Western-modern ways-of-knowing at a taken-for-granted disadvantage, even when the intent is to make space for both positions that extends beyond inclusion and tolerance towards dialogue and collaboration. Accordingly, this also complicates the entangled relationships held with/in school science for those

17 Latour (1993) refers to this as “particular univeralism”: a framework in which Nature is stable and outside of Culture in which diverse cultural positionings mediate access to knowledge about Nature, but in which “one society - and it is always the Western one - defines the general framework of Nature with respect to which the others are situated” (p. 105). In other words, it is a conceived of and enacted as an epistemic privilege.
18 This is a significant location to labour as some scholars, such as Cobern and Loving (2008), problematically articulate the corollary argument that the epistemology of WMS (i.e., epistemic realism) should be considered the best way of knowing Nature of its high level of alignment with a Cartesian ontology.
enacting other-than-Cartesian ways-of-being, such as Indigenous ways-of-knowing-in-being\(^{19}\), as they continue to be perceived as alternative but lesser ways of “reflecting” Nature as it is understood and enacted through (the singularity of) Cartesianism\(^{20}\).

1.2.3 **Towards wandering the pathways of science education anew.**

When reaching and reading singularity, particularly singularities (e.g., Cartesianism) that impede the possibility of Indigenous science to-come, it is productive to consider Cajete’s (1994) suggestion that: “Indigenous thinking honors the reality that there are always two sides to the two sides. There are realities and realities. Learning how they interact is real understanding” (p. 31). (Re)opening and re(con)figuring science education to be able to respond to and receive Indigenous science to-come might entail considering co-constitutive relations between what seems separate and seperable quantities marked (wholly) by relations of difference (e.g., Nature/Culture as nature-culture, decolonizing/colonizing as de/colonizing, possibility/impossibility as im/possibility).

To come-to-know the “two sides to the two sides” between, amongst, and even within WMS and IWLN, it is productive to consider science education as pathways. On pathways, Cajete (1994) states that,

> In travelling a pathway, we make stops, encounter and overcome obstacles, recognize and interpret signs, seek answers, and follow the track of those entities that have something to teach us. We create ourselves anew. *Path* denotes a structure; *way* implies a process. (p. 54, emphasis in original)

What might appear as a sedimented and stratified *path* is inseperable from its enactment, its journeying, its *way*. Such is important in differentially enacting the double(d) closure (i.e., enclosure [noun], enclosing [verb]) of modernity’s metaphysics that seek to make the ends (i.e., the path)

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\(^{19}\) Here, I use ways-of-knowing-in-being for three interconnected reasons. First, it is a nod to the notion that learning is always already a process. As Aikenhead and Elliot (2010) suggest, “the expression *Indigenous knowledge* is problematic because the word *knowledge* is embedded in a Eurocentric epistemology” (p. 322; see also Aikenhead & Ogawa, 2007). Rather, within many Indigenous languages, learning is not expressed as a product (i.e. knowledge, a noun) but rather as a process (i.e. coming-to-knowing, a verb). Peat (2002) states, “coming-to-knowing means entering into relationship with the spirit of knowledge, with plants and animals, with beings that animate dreams and visions, and with the spirit of the people” (p. 65). Second, coming-to-know is inseparable from coming-to-being. They are ongoing and interconnected epistemological and ontological processes that are deeply relational and holistically interwoven into the fabric of everyday life (Aikenhead & Michell, 2011; Cajete, 1994, 1999, 2000; Peat, 2002). Lastly, it is to signal plurality with a reminder that plurality does not entail a form of relativism (McKinley, 2007).

Furthermore, as Aikenhead and Michell (2011) state, “reading a book is not adequate for understanding specific Indigenous practices (e.g., berry picking or fishing), which invariably require experiential learning” (p. xii). Rather than seeking to reach the problematic closure and containment of *knowledge*, they propose that *appreciating* might be a more apt way of approaching Indigenous ways-of-knowing-in-being. Not only this, as Cajete (1994) suggests of the textuality of his own work on Indigenous ways-of-knowing-in-being, that it is a translation with/in, as well as for, academic traditions and that it is effectively something that is differentially produced through a differential ecology of relations (partially shaped by the vales of the academy): this relationship shapes what can be said, what cannot, as well as how.

\(^{20}\) This argument is fleshed out in greater detail within the dissertation, particularly Chapters 3, 4, and 5.
congruent with the means (i.e., the way). However, when *the* path is revealed as but *a* path, a multiplicity of possibilities opens up.

As the human, other-than-human, and more-than-human worlds that constitute a(ny) path “move in never ending cycles of creation and dissolution” (p. 43), it is necessary to engage in what Cajete (1994) refers to as “creative acts of perception. A free play of thought and an opening of the field.” (p. 19). This process requires, as has been the goal in this section, realizing that there are tacit, ever shifting infrastructures (i.e., like paths) that frame what is, is not, as well as *becoming* possible within a field. Rather than engage in the destruction of a path (if such were even a desirable possibility21) or complicit journeying on a path as is (upholding the status quo in which Indigenous science is to-come), I see my task as one of coming-to-know the “nature” of many of the paths that lay before me and others in science education, their possibilities and problematics, and to look for different *ways* (and potentially (re)open new *paths*) to journey through this field.

I consider wandering pathways anew as a process of “getting lost” within science education. Strategically straying off the beaten path or taking ‘the path’ in unintended ways is positioned “not as ‘losing one’s way’ but as losing *the* way— as losing any sense that just one ‘way’ could ever be prefixed and privileged by the definite article” (Gough, 2006a, p. 640, emphasis in original; see also Lather, 2007). Furthermore, as Gough (2006) states on “getting lost” in science education:

…to “wander” away from the semiotic spaces of science education textbooks and scientific media reports, and to experiment with making passages to hitherto disconnected systems of signification, is neither “haphazard” nor “careless” but a deliberate effort to unsettle boundary distinctions and presuppositions. (p. 640)

As I tactically wander within, against, and beyond the sedimented spaces of knowing in/of science education, I heed Alsop and Fawcett’s (2010) reminder that coming to know otherwise in science education requires being vulnerable and attuned to what can be known through the process of *not knowing*.

In the next section, I detail the methodological approach to decolonizing science education and research that guides this getting lost on the pathways of science education: deconstruction.

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21 Sami scholar Rauna Kuokkanen (2007) reminds of the tenuous path of critically inhabiting spaces – that one must always be critical and complicit – as to engage in *destruction* rather than *deconstruction* results (re)produces similar results albeit differently. There requires, in her words, a “subtlety and responsibility in the process of transforming the [institution of learning]. … proceeding in any other way would eventually backfire and merely too tight[ly] reinforce existing structures and discourse [through]… ‘irresponsibilizing destruction’” (p. xx; see also Spivak, 1994).
1.3 Second Orientation: (Re)opening Science Education to Indigenous Science To-Come through Deconstruction and Reconstruction

Deconstruction has been developed by the French philosopher Jacques Derrida and, very broadly, involves a critique of Western knowledge or thought. Derrida … showed how anthropological knowledge is governed by a philosophical category of the center (named Eurocentrism). The argument contends that in the last few hundred years Europe has constituted and consolidated itself as sovereign and subject by constructing the colonized according to the terms of the colonizer’s self-image. Deconstruction is the decentralization and decolonization of European thought… Hence, deconstruction is a deconstruction of the concept, the authority, and the assumed primacy of the category of “the West.” (McKinley & Aikenhead, 2005, p. 902)

Methodologically, this dissertation employs Battiste (2013a, 2013b) and Donald’s (2011) conception of decolonizing education as a “recursive process of deconstructing and then reconstructing” (Donald, 2011, p. 15) as an over-arching meta-approach to work towards Indigenous science to-come. Simultaneously, I heed the warnings of post-colonial theorists and theory that the potentiality of deconstruction and reconstruction lay in recognizing them as more-than deconstruction and re-construction as forms of taking apart and putting together (see Derrida, 1976; Jackson & Mazzei, 2012, McKinley & Aikenhead, 2005). Taking apart (i.e., destruction) through criticism, as McKinley & Stewart (2012) suggest, is a “seemingly potent but ultimately counter-productive strategy” (p. 545) in science education. Rather, Battiste (2013b) argues that approaches to decolonizing education “first and foremost must be framed within concepts of dialogue, respect for educational pluralities, multiplicities, and diversities” (p. 107). However, when criticism is perceived and enacted as taking apart, colonial logics are replaced in but one sense of the word: displaced but not always disrupted (see Kuokkanen, 2007; Spivak, 1994; see Chapters 2 & 3). Deconstruction works against not only the Euro-centered through Eurocentrism, but also the centering properties of Eurocentrism through endeavouring to dismantle its logics of either/or. In turn, as post-colonial theory presents Indigenous science to-come as a persistent ethical im/possibility, this dissertation tilts more heavily on the deconstructive side, (re)considering reconstruction as inseparable from

22 While Battiste (2013a, 2013b) does not come to state explicitly how she understands deconstruction or whom she draws upon, a persistent theme throughout this dissertation is generous and generative (mis)readings. Rather than criticize what some might perceive as a lack (as negation forecloses possibility), I see such indeterminacy as a gift of potentiality and of meaning that is productively on the move that might come to respond to diverse contexts (see Kuokkanen, 2007).

23 Donald’s (2011) use of deconstruction/reconstruction primarily hinges upon Indigenous-non-Indigenous relationships that are already being enacted. Here, deconstruction does not entail a destruction of the hybrid, complex, and contradictory space interfacing Indigenous and Western thought and being. Rather, it entails keeping an eye out for porous locations in order to reconfigure, rethink, and differently enact the relations that are there to create new and renewed possibilities for ethical relationality (see also Nakata, 2007a, 2007b). This metaphor is productive in differentially coming-to-understand the ways in which the post-colonial concept of de/colonizing is enacted throughout this dissertation.
deconstruction and as a form re(con)figuring (see Carter, 2005; see also Chapter 6). As the structure of science education is not reached and will never achieve a state of being “deconstructed,” re(con)figuring is a continued deconstruction, labouring between what a structure is, is not, and could be(come) in response to an otherness who is yet-to-come (e.g., Indigenous science to-come).

1.3.1 Common approaches to cross-cultural methodologies in science education.

Prior to tracing how deconstruction as methodological approach creates space for and supports wandering the pathways of science education anew, it is important to touch on the ways in which these problematic paths are usually journeyed upon. Just as teaching and learning in science education are increasingly considered through (socio-)cultural approaches (see Aikenhead, 2006a; Erickson, 2001), so too are its cross-cultural methodologies. As McKinley (2007) states regarding approaches to cross-cultural science education,

Dominating the field are approaches derived from anthropology, such as worldviews, collateral learning, and border crossing. The anthropological approach is a seductive one because it focuses on the culture and cultural practices of different groups and treats science as a cultural activity. (p. 220)

However, at the same time, “science educators are seldom also trained in associated disciplines, such as cultural studies” (McKinley & Stewart, 2012, p. 545). In turn, as McKinley (2000, 20007) and Carter (2004, 2005, 2010) state, culture comes to be perceived and enacted in ways that often come to reify colonial constructs that they are working against, albeit differently. For example, considering school science as having a culture does not necessarily “critique the Eurocentrism inherent in stable and unitary ideas of culture, identity, and context still to be found in some of science education’s more traditional comparative and cross-cultural studies” (Carter, 2004, p. 824). Modes such as worldview theory and border crossing might be apt for considering the experience of a student navigating between cultural spaces, but might not account for the power relations in place between these knowledge systems which occurs beyond the individual learner which produce the very borders they must cross (Carter, 2004; McKinley, 2007). However, this is not to state that culture should be jettisoned (thus reinforcing a status quo of science as a-cultural). Rather, as culture offers both methodological possibility and problematic, it is important to use and trouble this central referent to cross-cultural and multicultural science education. Deconstruction, states McKinley and Aikenhead (2005), provides such means to use and trouble culture within decolonizing and post-colonial science education methodologies as it accounts for both process and product of Eurocentrism and Cartesianism.
1.3.2  Deconstruction and/in cross-cultural science education.

Within this dissertation, I take a deconstructive stance that might be described as an “impossible ‘no’ to a structure which one critiques, yet inhabits intimately” (Spivak, 1993/2009, p. 316). Critically inhabiting science education entails refusing to inhabit it like that without refusing to inhabit it altogether: deconstruction is at once critical and complicit (see Chapter 3). In offering a succinct “how-to” for deconstruction\(^{24}\), Spivak (1976) suggests:

Deconstruction in a nutshell...[is] to locate the promising marginal text, to disclose the undecidable moment, to pry it loose with the positive lever of the signifier; to reverse the resident hierarchy, only to displace it; to dismantle in order to reconstitute what is always already inscribed. (Spivak, 1976, p. lxxvii)

Spivak (1976) describes the process of bearing witness to undecidability as being on the lookout for snags in meaning when it stops working as intended, in which the absence of unified meaning might come to threaten the very structure which it occupies. In short, this entails paying attention to, and making use of, concepts and categories whose meanings vacillate between a meaning and a constitutive otherness; intentionally (mis)reading them by tinkering with meanings otherwise unintended but potentially signaled by that which is there (see Biesta, 2009; Derrida, 1976; Spivak, 1976; St. Pierre, 2011a). Echoing Spivak (1976), McKinley and Aikenhead (2005) state of deconstruction in decolonizing science education that:

…the key to deconstruction is not the identification of the dichotomy and the inversion, (although that work is necessary and we do not wish to underestimate it), but the displacement of such thinking. In other words, how does one re-think these fundamental ideas? How does one displace those assumptions that make “natural” meaning possible? Furthermore, can deconstruction as a critique lift itself off the page to have any practical application? (p. 903, emphasis in original)

Importantly, McKinley and Aikenhead (2005) remind that deconstruction should not strictly be theory for theory’s sake. Rather, as Lather (2007) states, it is important to “[put] theory to work” by using theory (e.g., deconstruction) towards and without losing sight of the critical goals that one sets out to achieve (e.g., decolonizing). Deconstruction must be always already be deconstructing the theory/practice that keep the two separate and separable (e.g., producing practice as “atheoretical,” and theory as a practice of “armchair philosophy”): “the production of theory is also a practice; the

\(^{24}\) However, the question *What is deconstruction?* is always fraught; it is an approach that works against the metaphysical stasis that comes with the word “is” (see Derrida, 1976). As Spivak (1993/2009) also suggests, Derrida “does not develop a systematic description of this mode of operation. (There is, after all, no useful definition of deconstruction anywhere in Derrida’s work)” (p. 31). Thus, any account of deconstruction must always be partial as deconstruction is always already on the move; the discontinuity that is deconstruction is in itself dis/continuous such that Derrida does not have the final word on deconstruction (see Barad, 2010; Kirby, 2011).
opposition between ‘pure’ theory and concrete ‘applied’ practice is too quick and easy” (Spivak, 1988a, p. 275).

There are three inseparable binary relations that feature strongly within this dissertation: Self/Other, Nature/Culture, and ethical possibility/impossibility. I provide an introduction to all three in this chapter, as well as the literature that comes to inform how I wander the pathways of science education.

1.3.2.1  **Deconstructing Self/Other in decolonizing and postcolonial science education.**

Given that cultural (re)constructions of Otherness continue to be problematic within science education such that they (re)center colonial logics and subjects, a prevalent solution is often to reverse the gaze onto the Self (i.e., the colonial subject) of colonizing relationships (see Pillow, 2003). As Tuck (2009) articulates, researchers do not need, nor should they use the suffering of Indigenous, diasporic, and other post-colonial students as evidence of colonial violence and as ethical motivation for research (see also Andreotti, forthcoming). Above and beyond providing positive representations of these students, there is always the possibility to look back at the culture of power that produces this violence. However, to (too simply) displace the gaze by reversing the hierarchy does not always disrupt it (particularly if the gaze continues to operate similarly, albeit with a different target). Here, Lather (2007) suggests a double(d) reversal of the ethnographic gaze. Such a double(d) reversal entails both the literal reversal of studying those who do the studying (i.e., in order to reverse the direction of the ethnographic gaze), as well as the study of the ways in which those who do the studying study (i.e., in order to reverse the way in which the ethnographic gaze is produced). Such deconstructive Self-reflexivity might allow for the possibility of thinking without the thing with which you think (when the thing with which you think is part of the problem), producing the possibility for alternate ways of being and becoming science educator and researcher.

To this, Andreotti (forthcoming) adds that reversing and (re)opening the production of such a Self/Other binary also invites different ways of being-in-relation:

> if we use the same frames of being that create violence to resist violence, we will reproduce more violence. If focusing on thinking alone is not the answer, what else can we scale up so that we can remember to listen and relate to every being, not necessarily through conceptual language, but through our bodies and our spirits? …. We can renew our relationships, not only between ourselves, but with the land, with the animals, with the standing people, and with being around us, including the colonizers (Andreotti, forthcoming, pp. 5-6)

Here, inverting the production of the gaze also entails resisting a simple displacement of colonial violence and, further, houses the potential to disrupt it. I agree with Andreotti (forthcoming) that
such modes honouring all my relations, which includes recognition of the difficult ones, can be at once a luxury while simultaneously being a site of potentiality. As Indigenous Elders have offered to and modeled for me, there is something important in extending a genuine invitation a relationship-to-come, even if its potentiality is not enacted (see also Kuokkanen, 2007). Herein, I work to not negate the work science educators who might disagree with the very premise of the dissertation. Rather, I extend an invitation to dialogue across difference towards them.

Lastly, in considering the Self/Other binary, I recognize that it is important to move “the postcolonial critique of Eurocentrism beyond identity politics, to the level of an epistemic challenge to science” (McKinley & Stewart, 2012, p. 551). Spivak (1993/2009) states that to reduce scholarship to identity politics can be a way which the workings of power are (re)produced:

I have long held that in the arena of decolonization proper, the call to a complete boycott of so-called Western male theories is class-interested and dangerous. For me, the agenda has been to stake out the theories’ limits, constructively to use them. (p. x)

In other words, deconstructing the colonial Self/Other binary does not preclude any one identity from participating in the workings of power, even if the circulation of power is uneven and unequal across different identity positions (see also Spivak, 1988a). Furthermore, as Spivak (1994) states,

It seems more responsible that, instead of falling back on the deceptive simplicity of a proposition [(e.g., “a complete boycott of Western male theories”)] and taking that as sufficient fulfillment of … philosophical responsibility, … [we could] philosophize with all stops pulled out, without denegating [our] complicity, to present [such proposition] as pharmakon, what could have been medicine turned into poison. (Spivak, 1994, p. 34)

To strictly operate from an identity politics position in which “Western male theorists” (such as myself) are excluded runs the risk of stating that those excluded are “inherently” Eurocentric (i.e., being) rather than shaped with/in Eurocentrism (i.e., becoming). This risks foreclosing the space of possibility to not be Eurocentric like that (and invariably, leaving particular individuals “off the hook”). In turn, the theory-practices that I employ throughout this dissertation are selected (but not “validated” as non-Eurocentric or unproblematic) for their ability to displace and disrupt the metaphysics of modernity and (re)open science education towards Indigenous science to-come.

To rupture the Self/Other relationship, I turn primarily to the work of post-colonial scholars Gayatri Spivak and Jacques Derrida. Also, I employ Indigenous and decolonizing scholars Dwayne Donald and Martin Nakata’s work as it focuses specifically on the (already) interfacing of Indigenous and Western ways-of-knowing-in-being. Lastly, I also draw strongly on the work of (self-proclaimed) “reverse anthropologist” Frédérique Apffel-Marglin whose work significantly supports me in considering how one might double the reversal of the gaze onto science education.
(see Chapter 5), as well as how science’s Other-ness includes Nature. This is, of course, in addition to science education scholars who do this work (e.g., Carter, 2004; McKinley & Aikenhead, 2005)

1.3.2.2 Deconstructing Nature/Culture in decolonizing and postcolonial science education.

As Spivak (1993/2009) states, “if the lines of making sense of something are laid down in a certain way, then you are able to only do things with that something which are possible within and by the arrangement of those lines” (p. 34). Science education often dialectically subsumes, sublates, and sutures over many of the pluralities, multiplicities, and diversities called for in decolonizing and post-colonial science education. As detailed in previous (sub)sections, these enactments are achieved through an implicit and often taken-for-granted centering of Cartesianism25, while simultaneously working to erase other ontologies and Cartesianism’s own workings by presenting itself as the (only) ontology. Recall that Cartesianism is an ontological enactment through which the Nature/Culture binary is (re)produced and produceable.

I endeavour to work within and against this problematic structure that (re)constitutes science education; labouring within and against the clôture of metaphysics that is (and is always becoming) singular, stable, and subsumptive. To do this work, I turn to the work of critical science studies scholars such as Karen Barad, Bruno Latour, and Vicky Kirby as they explore the ways in which Nature and Culture are always already co-constitutive and deconstructing within WMS. Also, I turn to Tewa scholar of Indigenous science Gregory Cajete who articulates that Nature and Culture were never (fully) separate or separable within IWLN. Again, this is in addition to science education scholars who help me think this through (e.g., Bang & Marin, 2015).

1.3.2.3 Deconstructing ethical possibility/impossibility in decolonizing and postcolonial science education.

To reiterate, deconstruction and reconstruction are not de-construction and re-construction (see Jackson & Mazzei, 2012); this process is not destroying and then rebuilding. Deconstruction and reconstruction invariably share a relation of co-constitution. As Spivak (1994) outlines, the very possibility of reconstruction as ethical response to a call of otherness such as Indigenous science to come is premised on responsibility. In turn, ethical responsibility is inevitably premised upon the ability to respond:

It is that all action is undertaken in response to a call (or something that seems to us to resemble a call) that cannot be grasped as such. Response here involves not only “respond to,” as in “give an answer

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25 For example, at the time of writing, even auto-correct suggests that ontology is a singular affair (via grammatical suggestions; i.e., ontology rather than an ontology).
to,” but also the related situations of “answering to,” as in being responsible for a name (this brings up the question of the relationship between being responsible for/to ourselves and for/to others); of being answerable for … It is also, when it is possible for the other to be face-to-face, the task and lesson of attending to her response so that it can draw forth one’s own. (Spivak, 1994, p. 22)

In its multiplicity, responsibility for Spivak calls upon the ability to respond in the moment, to take responsibility for the (inevitable) inability to respond, and to continuously be responsible towards the very (im)possibility of responding to the other whose experiences, ways-of-knowing, and ways-of-being sit outside of the register of what we can know. The ability to respond is always, at best, partial as the Other to whom response is granted is, as Spivak (1988a) reminds, “irretrievably heterogeneous” (p. 284) and hence “non-narrativisable” (p. 284): that which is to-come can never fully be known as it is always already within the co-constitutive exteriority of that which can be known and responded to.

However, working with purpose but without guarantee is par for the course when it comes to deconstruction: “the philosophy of Destruktion [deconstruction] cannot be used to ward off accountability, answerability, responsibility ... It can only ever be a reminder of its open-ended and irreducible risk” (Spivak, 1994, p. 27). While working towards reconstructing science education with Indigenous peoples, places, and protocols in mind, I remain hyper-vigilant: the very frames through which recognition of Indigenous science to-come occurs are differential articulations of that which makes it such that this call “cannot be grasped as such” (Spivak, 1994, p. 22). It follows that the reconstruction herein focuses largely on the ability to respond on a continued deconstruction and (re)opening of the space of response within science education towards Indigenous ways-of-knowing-in-being.

To work within and against the binary of ethics as im/possibility, I draw from post-colonial scholars Gayatri Spivak, Jacques Derrida, as well as Rauna Kuokkanen. Also, I draw from feminist and post-structuralist scholars such as Judith Butler and Michel Foucault, as well as science education scholars who think with ethics as im/possibility (e.g., Carter, 2010).

1.4 Third Orientation: Structure of the Dissertation (AKA a Map to Wandering Pathways Anew)

Within this section, I provide a map of the networks of paths constituting this dissertation so that the pathways of science education might be wandered anew. In particular, I speak to the general structure of each chapter, as well as the methodological moves I make therein (e.g., positional vignettes, differential articulation of deconstruction). Following this, I outline the overall
arrangement of the dissertation as a whole, as well as some recommended strategies for reading. This is supplemented by a short outline of upcoming chapters.

1.4.1 Structure of the paths (i.e., chapters).

Within a larger network of paths, each chapter represents a differential hike, journey, or outing through a path of science education. Each journey is iterative, travelling through, against, and/or beyond a particular path, wherein the learning is enfolded and carried forward into the next trip. Representationally, this requires that each chapter as journey is presented as self-contained, yet interconnected. I regularly speak to the path being journeyed upon, as well as the ways in which I attempt (and encourage the reader) to “get lost” within said path to find a way back anew (see Cajete, 1994). Accordingly, each chapter generally includes its own positional piece, literature review, theoretical framework, methodology, analysis, and relational findings in a variety of forms such as open-ended questions, future orientations, and/or considerations and applications for situated practices – all of which come together giving the larger project of this dissertation shape as a network of paths towards responding to Indigenous science to-come in science education. As the network of paths come to cover a plurality of locations, this differential approach is in line with aforementioned post-colonial and decolonizing approaches to education and educational research that call for attentiveness and responsiveness to the relations that come to constitute these theoretical, methodological, and substantive sites (e.g., Battiste, 2013b; Carter, 2010; Smith, 1999/2012; Smith, Maxwell, Puke, & Temara, 2016). As this significantly inflects conventional dissertation norms (e.g., theory and methodology in separate chapters), I quickly speak to what this means for theory, methodology, and positionality.

With regards to theory, I align myself with Hawaiian scholar Julie Kaomea (2001) who works against calls for theoretical purity and transcendentalism, “consistent with the logic of post-colonialism and its declining emphasis on grand theories and narratives, my hybrid methodology, and thus my story, is intentionally eclectic; mingling, combining, and synthesizing theories and techniques from disparate disciplines and paradigms” (p. 68). Complicating and challenging the “rage for unity” (Spivak, 1976, p. xvi) produced by the clôture of modern(ist) metaphysics “demand[s] such theoretical innovation and flexibility” (Kaomea, 2001, p. 69). Accordingly, I give myself permission to relationally draw from a diverse and often commensurate range of scholars who support exploration of the three inflections of how Indigenous science is to-come. This theoretical plurality is purposeful as “many of the arguments against IK inclusion in the curriculum
are more of a philosophical nature” (McKinley, 2007, p. 210). Thus diverse approaches are required to (re)open a seemingly ever-threatened and -shrinking landscape of plurality. I attempt to critically inhabit this process by engaging theoretically with philosophies and arguments that do not typically hold a central position within science education (e.g., post-colonialism, decolonizing).

On the subject of methodology (i.e., the interconnection of theory-practice-ethics), most chapters use a deconstructive approach (see Derrida, 1976). As deconstruction is always already in relation to the context in which it is being applied, articulations and enactments of deconstruction differ from chapter to chapter, often building upon one another. In turn, it is more apt and useful to describe and situate these concepts with/in the proximal relations by which they are co-constituted.

Similarly, while it is commonplace and of importance to position oneself within decolonizing work (e.g., through identity), Carter (2004) offers that:

Postcolonialism’s ability to delve into these processes, and into the deeper ravines of referents like modernity, identity, representation, and resistance underpinning many theorizations of culture and difference including those used, but underexplored, within science education, can open spaces to generate different discussions about what science education is, and could be. (p. 821)

I take up this invitation to consider the ways in which identity, representation, modernity, and (neo-)colonization are inevitably intertwined through differential articulations of metaphysics by using and troubling “position” (see also Spivak, 1988a; 1993/2009). Thus, rather than offer a positional piece here in the introduction, you will find small and partial positional vignettes at the beginning of each chapter. This approach is by design and aligns with my understanding that positionality, too, is always already in relation (and is a differential articulation of all my relations). Such positionality cannot be disclosed through the self-sameness of identity, least not in the essentialized, stable, and singular understanding of the term (i.e., position rather than positionality). Rather, positionality is always contingent, partial, plural, and emerges in relation to the “scene of address” of the account that is being represented (see Butler, 2005). Furthermore, as Wildcat (2005), drawing on the work of the late Vine Deloria, reminds, the very concepts we hold are exceeded by lived experience and shared experiences can become a site of shared meanings across difference (see also Biesta, 2004; Bohm, 1996). In turn, the vignettes are also stories of why the very concepts under exploration are

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26Since, as Carter (2004) suggests, there is a “paucity of this type [(i.e., post-colonial and decolonizing)] of inquiry in science education” (p. 833), many concepts may seem foreign to some science education readers. Nevertheless, an effort is made to define terms and concepts as they appear and are leveraged towards decolonial goals within the body of the text.

27For example, in Chapter 4 and 5, the deconstructive metaphor is one of tinkering as it entails using things foreign to science education as tools to (re)open its structure. This builds upon deconstruction as the possibility, as well as intentional use of substitution as deconstructive methodology as used in Chapters 2 and 3 respectively.
always already deconstructing, require *deconstructive* engagement, and/or are productive sites of relational *reconstruction*.

### 1.4.2 Navigating the network of paths (i.e., dissertation).

The dissertation as a whole invites a process of wandering the pathways of science education, journeying the paths *anew* so that new *pathways* (e.g., Indigenous science to-come) might come to constitute the network of paths (see also Cajete, 1994; Kuokkanen, 2007). It is important to note that since the goal is to wander them *deconstructively*, “turn[ing] the outside in and the inside out” (Donald, 2011, p. 12, emphasis in original), each pathway presents its own challenges.

As the dissertation is not knowledge made but knowledge in the making, reading the dissertation invites engaged, active, and relational reading.

While not wanting to be (wholly) prescriptive about how the dissertation is to be read, it has been productively suggested by readers that this work is enjoyed most when read a chapter or two at a time. Like when one approaches a network of pathways covering a large expanse of territory, only the most experienced hikers should attempt a multi-pitch hike. Furthermore, as each pathway (as process and product) builds upon the previous one, it may even be worth revisiting a path a second time before continuing on. To assist in this process, the remainder of the dissertation is divided into two chapter arcs (discussed below) that are strongly connected to one another. Furthermore, because this dissertation is not meant to be read in a single sitting, you will find “trail markings” throughout that provide orientations through signaling preceding and forthcoming work. These may serve as a welcome reminder of where one has journeyed and where one is going.

The dissertation is broken into three two-chapter arcs as a suggested reading pace. The first section, *Critical Possibilities and Possible Critiques through Deconstructive Play in/of the*

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28 This is particularly the case because, as the preface might come to suggest, many parts of this dissertation first came-to-be as manuscripts. While the dissertation creates a narrative across the chapters, the recommendation to read the dissertation in parts cannot be separated from the density of ideas that manifest within individual manuscripts (which each have their own theory, methodology, ethics, and substantive content).

29 I thank my supervisor Dr. Dónal O Donoghue for pointing this property of the dissertation.

30 This advice may also be considered for individual sentences which utilize the theory-practice of deconstruction to deploy ontological indeterminacy in locations that are problematically singular(izing). Much more than a stylistic choice, such deconstruction leverages open a singularizing (neo-)colonial center, which itself is always on the move (see Spivak, 1993/2009, 1999). This means that there are often multiple *ways* to wander the *path* that is a sentence and that it is productive to linger and explore its possible possibilities.

31 Note that differing chapters might be of particular importance for diverse audiences. For example: readers firmly familiar with the multicultural science education debate and its largely adversarial workings may want to forego Chapter 2; readers already familiar with the post-structural turn and the ontological turn in educational research could potentially skip Chapter 3; readers most interested in pedagogical design and delivery may be most interested in Chapters 6 and 7.
Multicultural Science Education Debate, works within and against the tradition of WMS-based science education that (re)produces science educator and science education as a field by critically inhabiting the multicultural science education debate and critically questioning the potency of critique when enacted through the clôture of metaphysics. In the second section Tinkering with Ontology with/in the Multicultural Science Education Debate, the insight that ontology matters in the (re)construction of norms and practices through which Indigenous science is yet-to-come is pursued. The third and final section, De/designing and Delivering a Curriculum for Indigenous Science To-Come, uses insights from previous sections and works imperfectly towards leveraging these differential (re)openings towards a re(con)figuring of science education knowledge-practices through the development and delivery of a pedagogy.

A short synopsis of each chapter that appears in the remainder of the dissertation follows.

1.4.2.1 Overview of arc 1: Critical possibilities and possible critiques through deconstructive play in/of the multicultural science education debate.

Within Chapter 2, the multicultural science education debate around how, when, and if TEK and IWLN are included within science education (re)presented as (a) play. However, as the debate comes to be shaped by what Moulton (1983) refers to as the “adversary method,” an invitation to (mis)read the dialectic negation of conversation as dialogue is posited in an attempt to open a different space in which cross-culturalists and universalists might come to shared meanings. A significant question emerging from shared meanings within this chapter, and revisited in the chapters following, is How might considering scientific knowledge as knowledge-practice assist us in collectively working towards the shared goal of working against scientism in science education? This is significant to the overall scope of this dissertation as scientism often comes-to-be a central mechanism (alongside exclusivity and Eurocentrism; see McKinley & Stewart, 2012) through which Indigenous science is excluded, differencing, and deferred.

Within Chapter 3, the taken-for-grantedness, yet centrality, of metaphoric visuality in science is utilized as an opening to re(con)figure critique in science education. Specifically, three different optical metaphors are offered to inform gazing critically otherwise within science education: the mirror, the prism, and the diffraction grating. Drawing from the work of Latour (a critic of the mirror; 1993, 2004a), Foucault (the prism; 1979; 1997), and Barad (the diffraction grating; 2000; however, also note that each chapter is more than its substantive content as it also presents and builds upon methodology (i.e., theory-practice-ethics).
2007; 2010) each metaphorical visual technology and their relation to critique are respectively explored to inform new lines of critical questioning. Particularly, these critical metaphors are employed to ask theoretical, methodological, practical, and ethical questions of the multicultural science education debate presented within the previous chapter.

1.4.2.2 Overview of arc 2: Tinkering with ontology with/in the multicultural science education debate.

Within Chapter 4, Cobern and Loving’s (2008) call to consider scientific knowledge-practice as ontologically situated (articulated in Chapter 2) is used and troubled. As they refer to this consideration as uncommon, I explore the ways in which ontology is utilized to make common a science education status quo. In turn, I tinker with/in the common/uncommon dichotomy to work within and against this problematic, yet productive, statement. Particularly, I draw from “uncommon” (to science education) work at the ontological turn to explore how “ontological alignment” might be re(con)figured when ontology is no longer a singular affair that pre-exists scientific meaning-making.

Chapter 5 extends the work of Chapter 4 by positing Cartesianism as an ontology, as well as what it might mean to account for and be accountable to the ways in which this classical Western metaphysics comes to (co-)constitute knowledge-practices of WMS and science education. An interview with Dr. Frédérique Apffel-Marglin grounds this exploration. It is put into conversation with Cobern and Loving’s (2008) statement that cites “common sense” in the assertion that WMS offers an epistemologically privileged position from which to know Nature as it best aligns with ontology. Apffel-Marglin’s interview gives what she refers to as a “thumbnail account” of the birth of modernity (as an entanglement of economic, political, social, and religious forces and flows). This accounts elucidates how “common sense” has become common. Within the interview, she unpacks some of the taken-for-granted notions that are naturalized in making such a statement (e.g., values entangled with/in statements that are further entangled within a Cartesian ontology). These insights are then diffractively read through the practices of the multicultural science education debate to produce new insights, differently.

1.4.2.3 Overview of arc 3: Deesigning and delivering a curriculum for Indigenous science to-come.

In Chapter 6, I draw insights from the four previous chapters (i.e., Chapters 2-5) to work towards responding to Indigenous science to-come. Drawing from the concept of response-ability, I
(imperfectly) re(con)figure science education curriculum and pedagogy by opening it to its constitutive otherness. First, I think consider points of convergence and divergence between Karen Barad’s (2000, 2007, 2010) quantum philosophy-physics and Gregory Cajete’s (1994, 1999, 2000) Indigenous science in order to rethink scientific literacy by positing and enacting an(other) ontology. Second, I re(con)figure visual pedagogy and/in science education as a rife location to promote response-ability towards Indigenous science to-come. To achieve this, I highlight the re(con)figuration of photovoice, “a process by which people can identify, represent, and enhance their community through specific photographic technique” (Wang & Burris, 1997, p. 369) through deconstructive (mis)readings of the theories which constitute them.

In Chapter 7, I continue the re(con)figuring of science education by translating it into a context. Specifically, I identify the significant methodological moves made in order to pedagogically enact the process of “getting lost” and move towards relationally storying nature through digital-photography-assisted comics; the result of placing a re(con)figured photovoice in conversation with Indigenous storywork (e.g., Archibald, 2008) and comic book theory (e.g., McCloud, 1993). These insights coalesce to produce one possibility for school-based decolonizing science pedagogies: relationally storying nature (i.e. space, time, matter). I describe examples of the development and delivery curriculum that I designed and co-delivered with a collaborating teacher Kirk Gummow. In this curricular project, learners from two middle school classes in an urban Canadian school were encouraged not to ‘read’ nature through scientific literacy, but rather to narrate with nature as agential literacy through this pedagogical project. In other words, students differentially approached science through other-than-Cartesian ontologies, “getting lost” within/against many of the nodes of science in the process. This includes not only the relational storying of nature, but also the web of pedagogical activities that were used to engage students in further developing a relational practice and language that works towards knowing with nature within the context of their schools (e.g., mapping, sensory-affective registering of significant places, technical visual skills such as photography and digital comic mise-en-page). Furthermore, I analyze productions resulting from pedagogical design and co-delivery that work against the ontological closure of Cartesianism to produce a different horizon of possibilities for decolonizing science education. A particular focus is paid to the stories produced by/with students through reading them in ways that trouble knowing Nature (i.e., space, time, matter) through Cartesian modes (e.g., considering the agency of other-than-human agents within the school, considering non-linear space-time). This acts as a site to
explore the consequence for what scientific literacy is, is not, and most importantly can be in and as decolonizing and post-colonial science education.
Part 1: Critical Possibilities and Possible Critiques through Deconstructive Play in/of the Multicultural Science Education Debate
Chapter 2: Serious play: A Literature Review of Multicultural Science Education through and for (Socratic) Dialogue

The purpose of this chapter is to differentially revisit the multicultural science education debate, which is a central curricular location in science education that acts as both a potential entry point and problematic gate-keeping device for Indigenous science to-come, by inflecting it with a potentially less oppositional mode of meaning-making. Within this debate, it is generally agreed upon by science educators that there is a clear moral imperative to respect students from diverse cultural backgrounds within the multicultural science education classroom\(^\text{32}\). However, what constitutes respect and how it is enacted continues to be hotly debated. A significant contributing factor is how conceptions of respect are deeply intertwined with, including influenced and impacted by, considerations of “what counts” as science. This has produced two largely incommensurable positions around the inclusion of TEK (e.g., ethnoscience, Indigenous knowledge systems, Indigenous science): those who contest its status as scientific knowledge and those who champion it. However, as the process of debate enacted is commonly one of opposition, there is little room for meaning-made across positions. Above and beyond addressing the sources of knowledge that continue to uphold this serious debate, this chapter plays with/in the debate processes as a means of opening these foreclosed spaces in science education as both form and content lead to the excluding, differing, and deferring of Indigenous science to-come.

2.1 Prelude to (a) Serious Play

A few years ago during a graduate student conference, I was asked to take down a poster I was presenting minutes after I put it up. The campus-wide graduate research poster session had barely begun, as many graduate students hurried to hang their posters up. During this time, a member of the university’s Faculty of Science took note of my poster as he was walking through the exhibit, seemingly en route elsewhere. However, he stopped upon seeing my poster, his face reddening as his pace accelerated. “I’m going to request that you take this poster down,” he tersely demanded. Unsure as to why the request was being made, and unable to make sense of the physical cues he was exhibiting, I nervously asked, “Why?” The point of contention, he said, was the title of the poster,

\(^{32}\) Respecting Indigenous, diasporic, and other post-colonial students within the science education classroom is one of the key motivators within the culture of the multicultural science education debate for the inclusion of TEK. However, in classroom practices, the central focus is often on achievement; more specifically an “achievement gap” (without coming to understand the norms under which uneven scholastic achievement comes to be produced and produceable; see McKinley, 2007; McKinley & Stewart, 2012). However, as I have addressed elsewhere (Higgins, 2011, 2014a), the incorporation of TEK and IWLN within the science classroom is beneficial for all students.
“Shared horizons: A dialogue between Indigenous and Western science”, as well as its content below. In short, the poster highlighted my own work in cross-cultural science education in which I endeavoured to juxtapose and braid Western modern science (WMS)\textsuperscript{33} and local enactments of traditional ecological knowledge (TEK)\textsuperscript{34}, namely Inuit (i.e., Indigenous) science in the circumpolar region (see Higgins, 2011, 2014a). Feeling my pulse quicken, I asked him to elaborate with

\textsuperscript{33}It is generally agreed upon by science educators that perceptions of WMS are often partially (mis-)informed by particular stereotypical and monolithic images of scientists, as well as the notion that there is a way to do scientists think (e.g., the scientific method; see Aikenhead, 2006a). Nonetheless, there are still often similarities enacted across Western modern sciences with respect to beliefs about science held and enacted by many (but likely not all) scientists (see Aikenhead & Ogawa, 2007; Aikenhead & Michell, 2011). These include, but are not limited to:

- Nature is governed by laws that are quantifiable, generalizable, and predictable – hence – nature is knowable (or can and will be known in instances in which knowledge technology does not allow for the study of phenomena).
- Nature can be reproduced (for realists) or represented (for socio-constructionists) through scientific knowledge;
- The production of scientific knowledge is embedded within social contexts. However, “the rigour of [WMS] decreases subjectivity as much as possible” (Aikenhead & Michell, 2011, p. 43, emphasis in original) to make knowledge claims (quasi-)objective;
- Because scientific knowledge reproduces or represents nature (the latter with as little social and subjective noise as possible), scientific data speaks for itself;
- Constructing knowledge about the natural world (i.e., scientific knowledge) is the purview of humans and is represented or reproduced upon a static and (recti-)linear space and time.

\textsuperscript{34}Traditional ecological knowledge (TEK) is a term used by biologists and ecologists that became prevalent in the 1980s that usually signals “experience acquired over thousands of years of direct human contact with the environment” (Snively & Corsiglia, 2001, p. 11). TEK is often synonymous with terms such as ethnoscience, Indigenous or Native science, as well as Indigenous knowledge and Indigenous knowledge systems; of which, it has become the most prevalent in usage (McKinley & Stewart, 2012). These other terms are often preferred because TEK, like WMS, is a concept that is often (mis-)understood as a result of prevalent, pervasive, and problematic understandings (see previous footnote). These include “tradition” being defined in opposition to civilization and contemporaneity, “ecological” being reducible to ecology as defined by modern biology, and “knowledge” as discrete and separate not being an adequate referent for the relational knowledge processes from which TEK stem. Such mis- and missed representations are often complicated by under-representation (Aikenhead & Ogawa, 2007; Aikenhead & Michell, 2011; Snively & Corsiglia, 2001).

Similarly to WMS, there are many forms of TEK that are as diverse as the longstanding Indigenous peoples’ traditions from which these knowledges stem. TEK is not the binary opposite of WMS, however this is not to say that there are not significant differences between the two (Aikenhead & Ogawa, 2007; Aikenhead & Michell, 2011). However, there are often some beliefs about nature that are sometimes but not always shared:

- Reality is not dualistic (i.e., Cartesian) but rather monist. This entails that nature is not separate from culture, and that the physical and metaphysical are always already entangled. In turn, this entails that parts of Nature (i.e., the frequent purview of science) only make sense within and can never be separated from the whole of nature or reality. This whole can be referred to as an ecology of relationships or a “sense of place” (see Cajete, 1994, 2000).
- Knowledge of nature emerges through natural-cultural relationships with knowledge keepers who are either human (e.g., Elders) or other-than-human (e.g., plants).
- Relationships entail responsibility. Accordingly, since everything is inter-related, the ecology of relationships is sustained by responsibility.
- Nature, which includes space, time, and matter, is in constant flux and in a state of indeterminacy, whose indeterminacy and flux is dis/continuous (e.g., non-linear time). In turn, while nature is empirically observable, it is never fully knowable; ways-of-knowing-nature must remain open and dynamic to ongoing patterns of difference.
- Models developed empirically across generations do not function as representations of nature but rather as flexible and adaptive pedagogical tools for coming-to-know nature and be relationally accountable to one’s relationships.

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noticeable defensive and deliberate emphasis: “What is your issue with this?” The short of his response was that the friction was stemming from the cultural prepositions (i.e., Indigenous and Western) preceding the word science. In other words, as he told me, “there’s no such thing as Indigenous science, or Western science for that matter.” Agitatedly, he added, “There is only science.” Reading the issue as one of not recognizing Indigenous knowledge systems as valid and productive ways of knowing nature, I too was visibly frustrated. In an attempt to recover ground, I situated the cross-cultural work within a longstanding and ongoing conversation in science education. To this, he retorted that this type of engagement was not happening “in science”. With the tension escalating, both of us growing increasingly irritable, and neither hearing nor being heard, he repeated his demand to take down the poster. I outright refused. Our exchange ended as the faculty member went to seek out a member of the graduate student conference’s organizing committee to enforce his request.

As a science educator who has worked over ten years in Indigenous communities, making space for diverse ways-of-knowing-nature was and continues to be a commitment that is both personal and political. I could not simply take down my poster. While it cannot be stated with certainty, it is likely that the science faculty member also had his own commitments that beckoned him to firmly take the position expressed. Nonetheless, there is a part of me that wishes that this exchange could have played out differently. In hindsight, and giving the faculty member benefit of the doubt, the poster could have acted as a productive conversational pivot for both involved. What if I perceived his position of science as singular and universal as something other than a potentially disrespectful “the ends justify the means” approach to morality in teaching science? What if he perceived my position of advocating for scientific pluralism as something other than “anything goes” epistemic relativism? While I would like to think that we shared a common desire for science and science education that is rigorous and empirical engages nature yet not indoctrinating through cultural imposition, it appeared as though we had implicitly agreed to disagree before said conversation could begin. If the demand for me to take down my poster had not shut down the possibility of conversation, my reaction, rebuttal, and refusal certainly did. The act of attempting conversation further entrenched our respective positions, giving the impression that a combative and antagonistic relationship was the only type we could inhabit.

While this is but one experience from my perspective, the characteristics that mark it are not isolated. Michiel van Eijck and Wolff-Michael Roth (2007) state, “one can be surprised about the
fierce debate that currently shakes the foundations of science education” (pp. 927-928) and, I would add, the plurality of locations in which it is occurring. Often referred to as the multicultural science education debate, it is not strictly isolated to a singular place but extends to plural locations that are continuously and differentially shaped by Western colonial relationships. These include locations: a) where settlers remain and have become numerically dominant (e.g., New Zealand, Australia, Canada, United States, Peru, Taiwan); b) where colonial settlers have never reached majority and/or that have undergone formal decolonizing as defined by the United Nations (e.g., India and many African nations); and c) in which displaced diasporic communities live, whose forced migration from the lands in which their cultural identity developed is the result of colonialism past and present (e.g., descendants of chattel slaves in former British and French colonies, Hmong immigrants [formerly from Thailand] in China and the US) (Aikenhead & Ogawa, 2007; McKinley, 2007).

At stake are notions of “what counts” as science within the context of the multicultural classroom, and how their entanglement, impact, and influence constitute respect and how it is enacted towards culturally diverse students. Seemingly most polarizing, and of central significance in this inquiry, is the status of TEK as scientific knowledge (or equally valid to scientific knowledge).

I would argue that the ongoing debate is not the result of poorly formulated scholarly arguments. Rather, it is a symptom of the oppositional and antagonistic modes through which the multicultural science education debate operates (see McKinley & Stewart, 2012), such as was the case in the exchange between myself and the Faculty of Science member in the introductory vignette. For the multicultural science education debate to move towards shared meanings and

35 McKinley and Stewart (2012) suggest that the topic of TEK in school science is one “that has, in the past, been subsumed under wider concepts, such as multiculturalism, equity, and the like.” (p. 541). However, as post-colonial scholars of science education, they do not dismiss the locations in which inclusion happens as solely problematic. Rather, they critically inhabit these spaces as a site of both possibility and problematics through what could be read as taking a deconstructive stance. Taking a deconstructive stance is to “persistently to critique a structure that one cannot not (wish to) inhabit” (Spivak, 1993/2009, p. 284) by critically inhabiting the practices (linguistic or otherwise) at hand that shape us while at once troubling them.

As Spivak (1976) suggests, the language we possess also possesses us; thus, too simply moving beyond is “to run the risk of forgetting the problem or believing it to be solved” (p. xv) by reproducing it elsewhere, albeit differently. Thus, while recognizing the language of multiculturalism in science as a problematic entry point to consider the inclusion of IWLN, it is nonetheless the predominant entry point into conversations of, as well as gatekeeping device for, Indigenous knowledges in the science classroom. In turn, I also use and trouble this language.

36 The occurrence and recognition of classrooms as multicultural is recent. As McKinley and Stewart (2012) state: Solid decades of economic growth, and increased sensitivity to human rights, post-World War II, supported a steady improvement in education outcomes for [I]ndigenous students. As globalisation proceeded, teachers in Western countries faced classrooms of increasing cultural diversity, and anti-ethnocentrism was one aspect of the response, with teachers challenged to overcome their own deficit thinking. (p. 546)
understandings, it must become and remain an open process rather than a sedimented product. Open
cannels of communication allow for productive engagement across and between positions, rather
than a protective and prohibitive form of disengagement, such as that demonstrated within the
introductory vignette. As Elizabeth St. Pierre (1997) reminds us, the goal of educational research
should be to both “produce different knowledge and knowledge differently” (p. 175). As such, this
chapter seriously engages both within and against the norms that shape the culture of the
multicultural science education debate itself by differentially (re)presenting the multicultural science
education debate literature. However, the purpose here is not to produce new knowledge through the
advancement of either universalist or cross-culturalist positions as is traditionally the case. Instead, I
undertake, and provide tools for readers to engage the task of producing knowledge differently
through a differential critical engagement with the knowledge production process that occurs within
this debate in order to move towards the possibility of shared meanings.

2.1.1 Program of (a) “Serious Play” to-come

Differential knowledge (re)production takes the form of (a) “serious play” as means of
possibly working within and between the often “scripted” (i.e., well-established and entrenched)
positions of universalist and cross-culturalist in order to (re)open these foreclosed spaces of
meaning-making. In short, the “serious play” introduced here but expanded upon later signals an
entangled conceptual apparatus comprising Socratic dialogue, Bohmian dialogue, and Derridean
“play.” Together, these inform the textual strategies used as well as the practices of reading
advocated for. There are sharp distinctions between Socratic dialogue (i.e., Platonic form of
representation of live, face-to-face discussions between two “scripted” positions), and Bohmian
dialogue (i.e., the stream of meaning through which something is made in common), as well as a

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37 This distinction is significant. For example, Cobern and Loving (2008) engage a similar representational mode (i.e., a conversation) with the explicit “intention… to present the critical arguments in common sense terms” (p. 438) and the implicit one of demonstrating that the terms of their opposition (e.g., cross-culturalism through relativism) are untenable. However, this opposition is one that is largely imagined: cross-culturalists often repeat that they are advocating for pluralism rather than relativism and that they too do not wish the latter (see McKinley, 2007; McKinley & Stewart, 2012). Furthermore, as discussed further within this chapter, discussions whose aim are to emerge victorious, rather than to listen to one another, are pyrrhic indeed. These victories not only ring hollow following the defeat of an imagined opponent, but such combativeness does not generate new and shared meanings but works towards making meaning common by suturing over other meanings. As such, these engagements always already fail in their ability to produce common grounds from which to address the complex questions of multicultural science education: they (re)produce ideological divisions which take us away from the possibility of learning from on another and working towards shared goals (see Bohm, 1996; Latour, 2004a, 2004b).

38 I borrow the use of “foreclosure” here from Spivak (1999) to signal instantiated pre-emergence of meaning. In other words, foreclosure signals the ways in which the language we possess sometimes appears as already fully formed, stable, and signifying an ontologically stable location; foreclosure as the semiotic locations which resist (re)opening due to their naturalization as closed before the fact.
play (i.e., theatrical drama), and Derridean play (i.e., the always already present possibility and process of (re)significiation; see Derrida, 1976). However, through (a) “serious play,” this very term takes a double(d) meaning in that it is both a theatrical drama (i.e., a play) engaging with serious topics as well as a serious commitment and engagement with the (re)signification (i.e., Derridean play) of the concepts and terms within. Similarly, while the format of Socratic dialogue traditionally represents discussions between two parties, it also acts as an invitation to the reader who is open to being in a Bohmian dialogue with the text to create movement of meaning between the two positions (re)presented.

The goal of this chapter is to encourage and invite “serious play”, which can be read in two distinct ways. On one hand, it can be understood as a call for science educators to seriously (re)engage in the drama of foreclosed conversations around notions such as ‘what counts’ as science and other hotly debated issues within multicultural science education. On the other hand, it can be interpreted as an invitation for science educators to engage with the always already possible play of (re)signification of these notions and the associated positions. Together, serious play calls for the dialogical movement of meaning that occurs through and during the possible play of (re)signification, be it between people, concepts, or (scripted) positions, in order to produce a different set of possible possibilities39 emerging from discussions such as the one at the beginning of the paper as well as the one that is mimicked within the Socratic dialogue to come.

There are four ‘acts’ to this serious play. The first act sets the stage for the dialogue. I further expand upon the conceptually entangled notion of “serious play” through suggesting Bohmian dialogue as a means of working towards non-adversarialism, expanding upon the Derridean “play” of (re)signification, and proposing Socratic dialogue as a means of representing and producing this play. In the second ‘act,’ reading notes are provided. I describe the universalist and cross-culturalist positions participating with in the Socratic dialogue and beyond, and also make suggestions for readers looking to engage in the serious play of Bohmian dialogue. In the third ‘act’, the Socratic dialogue on multicultural science education is “played out”. Herein, both universalist and cross-culturalist characters enunciate points of contention and agreement within multicultural science education (e.g., “what counts” as science) while providing a space for readers to potentially engage

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39 Possible possibilities is an expression used throughout the dissertation meant to signal that not all possibilities are possible, nor equally possible. However, as possibility and impossibility forever vacillate, possible possibilities are always on the move (Barad, 2007). However, as Apffel-Marglin (2011) importantly notes, not all possibilities are desired nor desirable.
in differential meaning-making around these issues. The fourth and final ‘act’ that follows the Socratic dialogue is an exploration of how knowledge is both reproduced and potentially differentially produced within the multicultural science education debate. This section also engages with recent literature that endeavours to open up multicultural science education through (re)signification of locations that threaten to foreclose the possibility of further play (i.e., those which remain unresolved and unresolvable within the debate).

2.2 Act 1: Setting the Stage for (a) “Serious Play”

2.2.1 From the dialectic of discussion to Bohmian dialogue: An ethic for seriously playing together.

The positioning and approach enacted between the Faculty of Science member and myself within the introductory vignette could be stated to be what Janice Moulton (1983) calls the “adversary method.” She characterizes it by its aim “to show that the other party is wrong, challenging them on any possible point, regardless of where the other person agrees” (p. 156). Similarly, David Bohm (1996) might qualify the above engagement between the faculty member and myself as “discussion”. Discussion, having the same suffix as percussion and concussion, evokes imagery of verbal jousting in which speakers must beat, bang, and thump one another’s arguments in order for one meaning to emerge victorious through the dialectic negation of the other. In order to achieve this, the discussant must make common their view by subsuming, sublating, or suturing over those with whom they are discussing. This “making common” is often aggressive and adversarial, the shared assumptions required to engage in conversation on common ground are rarely reached. In turn, not only is it “not a good way to convince someone who doesn’t agree with you” (Moulton, 1983, p. 156) but it also breaks down the very possibility of communication (see also Latour, 2004a; Kirby, 2011). As was the case between the faculty of science member and myself, our respective refusal to consider the other’s point of view (re)entrenched our respective positions. As Bohm (1996) asks, “how can you share if you are sure you have the truth and the other…[similarly] has the truth, and the truthes don’t agree?” (p. 43). However, this did not mean we needed to concede our respective viewpoints. While there is always moments in which one must inhabit imposed norms within communicative spaces as a necessity, such inhabitation often requires the one conforming to allow parts of themselves to be dialectically negated. This type of subsuming, sublating, and suturing over often results in either a communication (i.e., a singular imposed meaning) or a null
communication (in which silences are rife with meaning; see Mazzei, 2007) but not necessarily communication as an open process of back-and-forth.

For these reasons, there is a call from scholars such as Bohm and Moulton for dialogue rather than the dialectic of discussion, a call to listen rather than strictly talk. While both dialectic and dialogue begin from an encounter in which two differing views on a similar or same topic encounter one another, their ethic of resolution differs. Dialogue’s Greek roots entail through (*dia*, as opposed to *di* which would simply signal two) the meaning of the word (*logos*). Rather than a dialectic contest between dichotomized views, dialogue acts as a stream of meaning, a process of communication in which those engaged are not concerned with defeating propositions or in which meaning is to be made common through imposition but rather a process through which meaning is being made *in* common. Because it is a non-adversarial model, a process through which shared meanings are made together, it does not require that the meanings interfaced together to be negated for something new to emerge. This creates space for the possibility for meaning-making positions in-between that are often lost and foreclosed in dialectic and discussion.

In and through dialogue, Bohm (1996) calls for “suspended action.” The suspension is a call to listen that is framed as both a listening to others and to oneself in that the act “listening” to how we listen to others can tell us much about ourselves, including the values that frame what and how

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40 While theories of dialogue as practice (e.g., Bohm, 1996) do not explicitly limit the number of participants involved within a dialogue to two, it implicitly groups them in and treats them as reversible communicative pairs (i.e., transmitter and receiver) in a manner similar to Socratic dialogue.

Further, note that, as Spivak (1994) states: “dialogue is, in fact, the accepted proper name of responsibility as exchange-of-responses, implicitly understood as the flow of propositions or constatations rather than responses from both sides” (p. 45). Dialogue as responsibility presents itself as a mode to be able to respond to Indigenous science to come (see Little Bear, 1994; Parry, 2008).

41 Alternately, the process and product of dialectic and dialogue can be unpacked as mathematical operators. Consider two competing premises, positions, or postulates: *A* and *B*. When brought into proximal relation, the type of ethic of resolution (i.e., the operator *x*) shapes what is produced (i.e., the resultant side of the mathematical equation).

Ideally, for dialectic, this interaction resembles such:

\[ A \times B = C. \]

Here, *C* is a third position or statement that would be a “best of both worlds” that is developed in an equitable mode of collaboration. However, due to always uneven relations of power, this ideal is almost never achieved or achievable. In instances in which the unevenness is more pronounced, the dialectic often bears closer resemblance the following:

\[ A \times B = A \]

This is what is referred to as dialectic negation: the absorption and/or annulment of the other term (here, *B*).

Some respond to this by articulating an ethic of incommensurability in which:

\[ A \times B = A + B \]

This entails that the two positions do not, cannot, and/or should not enter a proximal relation of co-production.

Recognizing that relations of power are always already uneven and unequal from the get go, dialogue strives to reach shared meanings without requiring the annulment of either meanings:

\[ A \times B = A + AB + A \]

This entails that both propositions or positions (i.e., *A* and *B*) stand while also producing a shared meaning as the multiplicative product of the two (*AB*).
we “hear.” Between the science faculty member and myself, there were diverse epistemic as well as affective cues that we could have sensed of ourselves and of the other (e.g., physical indicators of tension). They may have signaled the ways that we were being played by our respective personal assumptions. For example, if I could take my quickening pulse as an indicator of meaning on the move to partially glimpse at my then held assumption of epistemic universalism being diametrically opposed to respectful multiculturalism, perhaps I could have differently participated in the conversation. The purpose of “suspended action” is then to come to awareness, albeit partial, of how values are inflected, deferred, and deflected through our selves. It allows us to rethink the self-in-relation to the norms that shape how, who, and what we can be (see also Butler, 2005; Foucault, 1997; Mazzei, 2007; Peat, 2007). The action following a suspension period in which we consider gentle ways in which the situation can be re(con)figured, is a non-adversarial process through which shared meanings can potentially be made together.

2.2.2 The serious play of (re)signification.

Within the introductory vignette, one of the potential issues at hand was that the very terms and conditions that shaped engagement, such as “what counts as science,” were sedimented, stratified, and thus unable to move towards the shared meanings called for in Bohmian dialogue. In order for conversations around and about multicultural science education to be modes of dialogue rather than discussions, it required that the terms of engagement not be foreclosed before they are brought up. In order words, there is a need for the possibility of play. While the play that I am advocating for here is not the same as that of a child who might re-imagine a branch as wand, it is a useful metaphor with which to think as play is deeply tied to the act and possibility of (re)signification. (Re)signification is a conceptual process of un-binding and interchangeability of what something “is not” (e.g., a wand) and “is” (e.g., a stick). It is an interplay of absence and presence with respect to what is signified while retaining the signifier (Derrida, 1976). In turn, it allows for movement within the stream of meaning-making through the disruption and destabilization of stratified and sedimented meaning. Such de-centering creates a space of meaning making that allows for the production of positions in-between “present” and “absent”. Play is not a complete unraveling and an undoing, but rather a critical and complicit use of that which is played with, so that new meanings can take hold (Lather, 2007; Spivak, 1993/2009). Accordingly, when

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42 As Spivak (1976) suggests, such deconstructive play might offer “a way out of the closure of knowledge” (p. lxxvii).
that which is played with is no longer the material of children’s games, “play can be serious business” (Mazzei, 2007, p. 22).

2.2.3 **Socratic dialogue as a serious play.**

For revitalizing critical conversations that mobilize meanings of what quality multicultural science education “is” and “is not”, it is useful to think through a medium that works within and against the adversarial and scripted discussions operating within the field: Socratic dialogue. Plato’s Socratic dialogues are often read as a representation of a live, face-to-face discussion between two scripted positions. These positions are usually in unresolved, and potentially unresolvable, opposition to one another in a manner that is not so dissimilar from the introductory vignette. However, as Richard Smith (2011) reminds us, while it could be said that Socratic dialogues are but another form of representation, they are even moreso a textual invitation to think across and between the positions presented within. As Socratic dialogue is never fully captured by one definition or the other, holding these two differing readings of Socratic dialogue in tension make it an effective choice for thinking about multicultural science education. Given the ways in which the positions discussing multicultural science education are scripted, Socratic dialogue offers itself as an effective medium through which to represent a possible discussion, hence allowing for working within the script (e.g., TEK’s status of “counting as science” defended or denied). Furthermore, Socratic dialogue’s implicit invitation to dialogue across differently positioned concepts and commitments allows for working against the script (i.e., toward the possibility of shared meanings).

In addition to this textual invitation, Socratic dialogue provides the disruption and destabilizing through serious play required for the stream of meaning associated with dialogue. As Smith (2011) elaborates: a) Socratic dialogues are strictly imitations, b) imitations are always a form of play, and, accordingly, c) Socratic dialogues are never more than (a) play. Mimesis or imitation creates “an opportunity to adopt ‘alternative persona’ as a mechanism for addressing difficulties” (Turnbull & Mullins, 2007, p. 94) and playing with/in difficult positions. Although the universalist and cross-culturalist characters (re)presented within the upcoming Socratic dialogue are but imitations, seriously and respectfully engaging with them and their interplay means not turning them into caricatures of their positions. While Socratic dialogue is long known to engage in serious topics, it is a mode in which seriousness and playfulness are always in tension and inverting so that “they do

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43 While I lean towards a cross-culturalist position, it is productive for me to ‘occupy’ a position that leans towards universalism, even if it may be difficult for me, in order to think in ways that are productive rather than protective and prohibitive (see Spivak, 1976).
not form a fixed binary” (Smith, 2011, p. 230) as they are always already enacting the play of (re)signification. In addition, as it is (a) play with serious topics, “most attempts in the dialogues to reach a definition—of courage, friendship and so on—fail resoundingly” (Smith, 2011, p. 223). This “failure” to reach fixed and foreclosed conclusions or outcomes has much to do with play’s productive prevention of foreclosure through keeping meaning on the move. Accordingly, this generates a space for meaning making that is never fully prescriptive (i.e., meaning is not already made for the reader but rather always open to a certain degree of interpretation), and always open to further play (i.e., meaning is open to the possibility of (re)signification as the context under which it is signified differs). For this reason, Socratic dialogue acts as an invitation to the reader to engage in their own playfulness with the ideas found within, to play with serious notions that desire to be (re)produced differently.

2.3 Act 2: The Program for (a) “Serious Play”: a Primer for Playing Along

2.3.1 Who is playing (or played)?

The Socratic dialogue intentionally plays within the period when this debate reached its peak. As such, this dialogue primarily focuses on and draws from what van Eijck and Roth (2007) refer to as “one of the landmarks” (p. 927) of multicultural science education (see also McKinley & Stewart, 2012)\(^4\), as well as some of the pieces the symposium authors were responding to. Accordingly, the “key players” and their respective scholarship primarily informing and inspiring the universalist account are the work of William Cobern and Cathleen Loving (2001), Michael Matthews (1994), Harvey Siegel (1997, 2001), and Sherry Southerland (2000). Similarly, the cross-culturalist position which is “played out” draws on the scholarship of Bradford Lewis and Glen Aikenhead, (2000), Gloria Snively and John Corsiglia (2001), as well as William Stanley and Nancy Brickhouse (1994, 2001).

Within the field of science education, universalists are those who uphold the belief that WMS is the best, most valid, and/or powerful way of knowing the natural world. Furthermore, universalists see WMS as a knowledge practice that is quasi-objective, quasi-neutral, and/or quasi-transcendental vis-à-vis culture. On the subject, Matthews (1994) states that universalists:

… regard science as an intellectual activity whose truth-finding goal is not, in principle, affected by national, class, racial or other differences: science transcends human differences… This universalist

\(^4\) This landmark is, notably, a symposium in the journal *Science Education* (volume 85, issue 1). Despite its age, it remains relevant and significant. As McKinley & Stewart (2012) suggest, that since the publication of this symposium, “we have not progressed far with our arguments” (p. 547).
view recognizes that while aspects of culture do influence science, nevertheless cultural considerations do not determine the truth claims of science. (p. 182)

WMS’s epistemic superiority with regards to knowing nature is substantiated by WMS’s ability to explain, predict, empiricize, and stabilize natural phenomena, and apply this scientific knowledge to produce technologies that are unique (e.g., airplanes, modern medicine). Because WMS can at once be framed as culturally specific and universal, universalists within the multicultural science classroom continue to deliver science education curriculum which is about enhancing students’ scientific literacy by developing an appreciation, and understanding, and applications of WMS in everyday life. However, recognizing that universalism and multiculturalism are not a mutually exclusive and dichotomous, universalists endeavour to instructionally provide culturally diverse students whose opportunities to learn WMS in ways that are respectful of that diversity.

Within this Socratic dialogue, the universalist character’s account and engagement is primarily inspired and informed by the aforementioned scholars who take this stance with respect to multicultural science education. Also, in keeping with the goal of “serious play,” these accounts are inflected by recent scholarship that revisits the multicultural science education debate as a means of working towards shared meanings from a universalist position (e.g., Cobern & Loving, 2008; El-Hani & de Ferreira Bandeira, 2008; El-Hani & Mortimer, 2007; Zeyer, 2009).

Cross-culturalists are those who take up the pluralization and proliferation of scientific perspectives, and the localization of scientific knowledge without characterizing knowledges as relativistic (see McKinley, 2007). Cross-culturalists accept and promote the idea that TEK can and should be considered “equal” to that of WMS. This does not entail treating them equal (i.e., the same) but as equally valid. Cross-culturalists work from the assumption that because WMS stems from the dominant, hegemonic culture, many students who are not of that culture will experience science education as a form of dominance and hegemony. This experience is, in part, rooted in the valuation of WMS through decentering and devaluing of their own cultural knowledge. As a result, cross-culturalists uniquely endeavour to reform curriculum in addition to modes of instruction. With respect to science education curriculum, there is a commitment to create space in which TEK is included and simultaneously decenters WMS (see Aikenhead & Ogawa, 2007; Aikenhead & Michell, 2011). It is important to note that what is argued for here is not a teaching of all non-Western-modern bodies of knowledge, which could result in relativism, but rather an inclusion of diverse and longstanding empirical ways-of-knowing the natural world. With respect to instruction
within the multicultural classroom, the focus shifts from having students accept culturally diverse scientific notions towards developing understanding and appreciation. This often entails that cross-culturalist teachers assist their students in respectfully and meaningfully navigating cultural spaces that are not their own without the requirement that students abandon whichever way-of-knowing-nature that they are further developing.

In this Socratic dialogue, the cross-culturalist account and engagement is primarily inspired and informed by the aforementioned scholars who take this stance with respect to multicultural science education. To engage in the play of (re)signification, the cross-culturalist account is also inflected by revisitations of the multicultural science education debate that works towards shared meanings from a cross-culturalist position (e.g., Alsop & Fawcett, 2010; McKinley & Stewart, 2012; van Eijck & Roth, 2007).

It is important to note that while there are often internal similarities within both of these positions in terms of how they are both defined and enacted, there is also diversity. While the characters within the dialogue are a universalist and a cross-culturalist who are composite characters of the scholars who inspired this dialogical inquiry, there is not a singular way of being either a universalist or a cross-culturalist. While we should perhaps change the terms of the conversation to account for universalisms and cross-culturalisms, it is generally the case that both universalists and cross-culturalists will internally agree on the notion that WMS is or is not the most or only valid way of knowing the natural world respectively. However, the strength of such a “what counts as science” claim and other interrelated claims varies greatly within both positions, as well as the degree to which one embodies such beliefs within their research and teaching practices. It could even be argued that one need not consciously or explicitly hold the belief that WMS is or is not the most or only valid approach to be a universalist or a cross-culturalist respectively but rather that any and every science educator’s curriculum and pedagogy can implicitly demonstrate and convey such commitments (see Carter, 2004, 2010; Higgins, 2014a; Sammel, 2009).

These normative and counter-normative values are always already circulating and inflecting the signification of what it means to be science educator. As such, it is worth highlighting here that the strict use of two characters is not an attempt to present them as the universalist and the cross-culturalist. Furthermore, even if that were the goal, the ongoing play of (re)signification makes it such that the position, even if there is an attempt to fully account for the range of diversity, is always exceeded, ruptured, and overturned. In other words, even in a more comprehensive and expansive
definition of both universalist and cross-culturalist positions, there is always already someone who identifies as either but only partially fits within. Rather than attempting to engage in the impossibility of presenting an essence, this dualistic choice is made as a means of, first, working within the constraints that are posited by Socratic dialogue as a methodology. Secondly, it is an attempt to reproduce some of the particularities that occur through the adversary method. In particular, the assumption that:

the only, or at any rate, the best, way of evaluating work … is to subject it to the strongest or most extreme opposition. And it is assumed that the best way of presenting work … is to address it to an imagined opponent and muster all the evidence one can to support it. (Moulton, 1983, p. 153, emphasis in original)

This imagined opponent is often the most radical proponent of that which is considered the adversary. While scholars often see their own encampment as rich and diverse, through the adversary method, the opposing side often becomes a parody of itself. As a result, the imagined adversary who is addressed is often positioned in a manner that few, if any, scholars occupy. Universalists are not-so-gently cast as wholly privileging epistemic claims (through the norms of Western modernity) over moral or ethical ones, and vice versa for cross-culturalists. This creates perceived positions which are either strawmen or deeply untenable. If more modest positions are not more frequently discussed it is because scholars “who cannot be recast into an adversarial mold are likely to be ignored” (Moulton, 1983, p. 155). In some ways, like Socratic dialogue, the multicultural science education debate has become a scene where drama (i.e., the serious matters of “what counts” as science) and comedy (i.e., the parody-like positioning of adversaries) alternate and seep into one another.

2.3.2 Rules for (a) serious play.

Serious play is not something that occurs on its own⁴⁵. Rather, the act of “playing” (i.e., (re)signification) is a process that requires both players (e.g., “readers”) and played (e.g., texts). Furthermore, “playing” occurs through the movement in-between the two. Consequently, as a reader

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⁴⁵ As dialogical approaches are infrequent within science education, this following section is intended to provide insights into how one might engage in this process. Furthermore, as Bohm (1994) posits from his work with artists, science has much to learn about questions of aesthetics, affect, and emotion and their respective role in process of knowledge production (and reproduction):

Long before the scientist is aware of the details of a new idea, he [or she] may ‘feel’ it stirring in him [or her] in ways that are difficult or impossible to verbalize. These feelings are like very deep and sensitive probes reaching into the unknown, while the intellect ultimately makes possible a more detailed perception of what these probes have come into contact with. Here, then, is a very fundamental relationship between science and arts, the latter must evidently must work in a similar way, except that the whole process culminates in a sensually perceptible work of art, rather than in an abstract theoretical insight into nature’s structural process. (p. 46)
you are encouraged to engage with the Socratic dialogue in a manner that is dialogical (i.e., so that there is movement in-between your views and the views presented within the text and something is made *in common* through reading), rather than dialectic (i.e., so that either your views or the views presented within the text are *made* common through reading). Here, the practice of suspended action is significant as a lived practice of dialogue and a (partial) coming-to-awareness of what we think, as well as how what we think is produced and produceable.\(^{46}\)

Achieving dialogue through suspended action, be it between people, texts, or ideas, is not such a simple task as we often hold, and are held by, assumptions that make it difficult for us to know differently. On this, Bohm (1996) states that the assumptions we always already hold are entangled within the meaning-making process. They not only shape and are shaped by what we know (as representations), but also how we come to know (as the world presents itself to us):

… representation is not only present in thought or in imagination, but it fuses with the actual perception or experience. In other words, the representation fuses with the “presentation,” so that what is “presented” (as perception) is already in large part a re-presentation. (p. 64, emphasis in original)

In other words, as difference presents itself in the world, the assumptions that frame our thought subsume what is perceived within a representation, hence producing sameness. If we seriously desire being open to difference, Bohm (1996) states that there is a need to “go into all the pressures that are behind our assumptions... into the process of thought behind the assumptions, not just the assumptions themselves” (p. 9, emphasis in original). However, as Bohm (1996) states, “thought is not proprioceptive” (p. 29). In other words, thought is incapable of perceiving itself. It is impossible to simultaneously think about something and think about how we are thinking about something. Furthermore, the privileging of one is almost always at the expense of the other (see also Barad, 2007; Lather, 2007). Despite the impossibility of fully thinking about how we think, this does not mean that we are “off the hook.”

Because thought is incapable of perceiving itself, Bohm (1996) suggest paying attention to the affective and embodied movements occurring alongside thought. This, he suggests, might offer a means of differentially thinking about how we think while working towards the suspension of our assumptions. As Moulton states (1983), such “reasoning has largely been ignored by [scholars] because it is different from the reasoning used to address an adversary and it is too complex and interrelated to be evaluated by counterexamples” (p. 160-161). As such, considering that which is

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\(^{46}\) (Re)opening science educator as location is an important project in the (re)opening of science education towards Indigenous science to-come. This is because educators are important performative agents who *do* and *undo* science education’s circulating constructs, categories, concepts (see Higgins, 2014a).
usually excluded from consideration in meaning making processes can become a useful tool in producing knowledge differently.

These affective and embodied movements of thought are not only much more (self-)perceptible than thought but also hold a direct connection to thought:

Movements are taking place inside you – physical feelings – the heart beat, the blood pressure, the way you breathe, the way your body feels tense; and also the kinds of thoughts that go along with these feelings. You can observe these things, be aware of them, and their connection. (Bohm, 1996, p. 84)

While a consideration of sensorial or affective cues on their own might not provide direct insight into our assumptions and could also be considered an act of navel-gazing, Bohm (1996) states that they are nonetheless indicators that the process of knowing is occurring. Furthermore, not only are they connected to thought but also part of thought. For Bohm (1996), thought is “part of a material process” which happens with/in “the brain, the nervous system, [and] the whole body”, such that thought is not and should not be considered as disembodied and separate from affect as they are “all one system” (p. 94). Accordingly, sensorial or affective cues should be thought of as constitutive parts, and signals of the process of thought. Whether this process is one of knowledge production (i.e., new meaning being made of experiences or perceptions) or reproduction (i.e., new experiences or perceptions being fused over by previously held meanings) of knowledge, emotional and embodied indicators provide a rich entry point for attempting to think about how you think.

Therefore, as you read the Socratic below dialogue below, there is an explicit invitation to attempt to suspend the moments in which you would want to interject and pay attention to your feelings, both emotional (e.g., frustration) and physical (e.g., furrowing of the brow) as they become productive sites of inquiry into how we think about how we think (e.g., the systems and norms through which thought are inflected). If we take the idea that playing requires both players and that which is played, not only does a text require a reader for (re)signification, but it may be productive to think about these affective and sensorial movements as one of the ways in which the text is playing the reader.

2.4 Act 3: “Two Science Educators Walk into a Bar”: a Socratic Dialogue on Multicultural Science Education

Persons of the Dialogue: UNIVERSALIST (U); CROSS-CULTURALIST (CC)

Scene: Two multicultural science educators, one a universalist, the other a cross-culturalist, meet to discuss teaching practices over a pint of their favorite form of fermentation.
U: Hello [CC]. I know that in the past, we haven’t always seen eye-to-eye on what multicultural science education might entail; I thought that today we could attempt to begin our dialogue from a point on which we both agree. I brought with me a definition of multicultural science education upon which we should both be able to concur:

Multicultural science education is a construct, a process, and an educational reform movement with the goal of providing equitable opportunities for culturally diverse student populations to learn quality science in schools, colleges, and universities. (Atwater & Riley, 1993, p. 664)

CC: Hello [U]. Great idea! This is certainly a view of multicultural science education that I can get behind. I take it this is also the case for you, having picked the definition.

U: You are correct.

CC: Although we may both agree on the definition, I fear that we may read, and implement the same definition differently.

U: How so?

CC: I believe we differ in how we might interpret what is meant by “quality science.”

U: In that, like Southerland (2000), I view “quality science” as “inquiry characterized by reliability on evidence and reason with the goal of understanding an objective, external, physical world” (p. 290)?

CC: Yes, and that I, like Masakata Ogawa (1995), characterize science as “a rational perceiving of reality” (p. 588, emphasis in original)47. That is not to say that our respective definitions are incommensurate. However, partnering words such as reliability, evidence, and external with reason gives me the impression that there is a particular form of reason that you may be privileging through this process. Nonetheless, I am more concerned with how your definition of science is enacted within and through your teaching practices, particularly around “what counts” as science. If I may inquire, which systems of knowledge describing the physical world could be, should be, and are taught as “science” within your science classroom?

U: For the most part, my science education practices revolve around canonical understandings of science. In other words, WMS is primarily what is taught in my classroom. While I do not shy away from, nor am I opposed to, teaching other scientific viewpoints and meaning-

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47 As Aikenhead and Ogawa (2007) elaborate: The word rational does not signify a universalist rationality, but a rationality founded within the cultural context of use… Perceiving means both the process of constructing what is perceived to be reality through the participation of a group of people, and their resultant mental constructions of reality. (pp. 543-544, emphasis in original)
making structures for understanding the natural world, WMS is the most effective and useful system for working towards knowing nature.

**CC:** Is it fair here to state that the way in which you address multiculturalism in your classroom is largely instructional rather than, or in addition to being, curricular?

**U:** Yes, that would be a fair statement.

**CC:** Before we address instructional questions, I would like to ask you a few curricular ones.

**U:** Go ahead.

**CC:** Within science education curricula, the belief of WMS holding a position of scientific superiority is one that is often and simply taken-for-granted. However, this is not an accusation I am making of you. I assume that your centering of WMS is an informed choice. Could you justify this claim you make for WMS?

**U:** First, WMS demonstrates the properties that are at the heart of “quality science”: scientific knowledge and theories that are genuinely testable, predictive, and explanatory. Secondly, this is not to say that other ways of knowing the natural world are ineffective or not of value but rather that WMS best matches the criteria I have outlined previously.

**CC:** While I recognize the desire to make utilitarian curricular choices within educational spaces, it is also important to think about what is being maximized through these choices as well as how and why these choices are being made. My primary concern here is that how you define science and implement educationally might be at odds with “providing equitable opportunities for culturally diverse students” (Atwater & Riley, 1993, p. 664). In other words, taking such a stance is potentially disrespectful to students whose culture might not align with that of WMS48, be it in the context of science education or elsewhere.

**U:** I’m not sure I follow as to how my curricular conception and instructional delivery of science education might be inequitable or disrespectful, but I am willing to hear you out. Go ahead. Make your case.

**CC:** Since science is dependent upon an intersection of particular experimental systems, communities of researchers, organizational modes, as well as historical circumstances, all of

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48 As Glen Aikenhead and Dean Elliot (2010) point out, the culture of school science potentially produces experiences of assimilation or acculturation rather than enculturation for the vast majority of students (~90%; see also McKinley, 2007). In other words, most students run the risk of experiencing science education as a form of dialectic negation rather than a dialogical encounter.
which contextualize the generation of scientific knowledge, would you not agree with me that science is a situated practice?

U: Yes, I would have to agree.

CC: Similarly, since education is linked with culture, gender, history, socio-political and socio-economic context, amongst other factors, would you agree that education is also a situated practice?

U: Yes, go on.

CC: Should it not be argued then that science education, like its two constitutive parts, science and education, also be a situated practice?

U: Agreed.

CC: Then, should science education, as a situated practice, not also draw upon and reflect the contexts within and through which it emerges? This might entail many different things when considering a variety of contextual elements such as the constitution of the student body. For the sake of this conversation, I would like to clarify that I am referring specifically to the inclusion and reflection of TEK, be it called ethnoscience, Indigenous science, Indigenous knowledge systems or something else altogether, to enhance students’ learning within the science classroom.

U: I would cautiously agree with you that science education should draw on and reflect the educational context. As I mentioned earlier, I am not opposed to teaching bodies of cultural knowledge alongside scientific beliefs, because teaching TEK, ethnoscience, and other forms of culturally-specific scientific understandings can enhance students’ learning by illustrating what WMS can do that which other approaches to the natural world cannot. In other words, including non-canonical understandings of science can be a way of showing that not all thoughts are equal in all contexts. The inclusion of ways of knowing nature beyond WMS in the science classroom is not something that is agreed upon by all universalists. However, I do not view the exclusion of TEK or other approaches to knowing nature as an essential practice within science education. As an aside, I would like to inquire into the criteria you are utilizing for the systems of knowledge whose inclusion you are arguing for.

CC: I can certainly elaborate upon this. As you will recall, we have discussed and agreed upon earlier that science needs to be conceived as socio-culturally situated. However, this is not to say that it is only situated in this manner. As Karen Barad (2007) states, it is important “to
remember that there are cultural and natural causes for [scientific] knowledge claims” (p. 40, emphasis in original). Accordingly, the ways-of-knowing-nature that I am arguing for are not only culturally situated, but also rooted in natural empiricism. Not only is TEK empirical in its engagement with one’s natural environment, but it is also a longstanding, intergenerational human engagement whose knowledge traditions often span thousands of years. As such, I am arguing for a pluralism of ways-of-knowing the natural world in which both culture and nature are significant and significantly engaged factors in the development of the knowledge claims being made.

U: While I do not wish to make a “slippery slope” argument, would Creationism fit here?

CC: It certainly is not my intent to exclude Western ways-of-knowing the natural world that are not WMS as there are multiple forms of TEK stemming from the West. However, as I understand it, Creationists’ knowledge claims about the natural world are primarily, and possibly strictly, culturally-based (i.e., around biblical scripture). As it does not meet the criteria of natural and cultural causes for knowledge claims, Creationism would not, and should not, be included with the other bodies of knowledge that “count as science”. The pluralism for which I am arguing need not and should not be an “anything-goes” form of relativism.

U: Thank you for the clarification.

CC: It is my pleasure. Furthermore, I think you would agree with me here that the science classroom should not be a place of dogmatic education.

U: I do agree here.

CC: Then, if you will allow, I would like to ask further questions around your earlier statement around how, in your science education practices, you might include other bodies of scientific knowledge and compare them to WMS. In particular, I am curious as to how you might respond to the oft-enunciated claim that a WMS-centered science curriculum has been and continues to be indoctrinating when there are pluralistic perspectives with the classroom.

U: Certainly, go ahead.

CC: Do you believe that it is possible both to respect youth whose culture is reflected in TEK and represent that TEK in terms of contrast with, indeed in terms of deficit to, WMS? Furthermore, if WMS is maintained as the primary curricular content in light of plurality, how do you avoid the pitfalls of this becoming a form of dogmatism?
If it is done with caution, sensitivity, and care, I believe that this comparative process can be engaged in and taught respectfully. Also, one can teach science without demanding that students change their beliefs, or denying them altogether. I recognize that historically there have been many cases in which interfacing WMS with other ways of understanding the natural world have been problematic in that they have forcefully produced totalizing discourses, cultural silencing, and marginalization. As Cobern and Loving (2001) state, 

The problem is not that science dominates at what it does best: the production of highly efficacious naturalistic understanding of natural phenomena. The problem is that too often science is used to dominate the public square as if all other discourses were of lesser value. (p. 62)

I am not advocating for education that is disrespectful or impositional. The issue at hand is not the comparative work, nor the centering of WMS, but rather the educational mode through which it was done. One can engage in teaching WMS without it devolving into scientism through its unquestioned and unquestionable privileging at the expense of other forms of knowledge.

Would you care to elaborate on this? I do not understand how you can simultaneously respect an individual while not affording validity to their culturally-based scientific knowledges.

While these comparisons may not hold certain cultural knowledges as equivalent to WMS, this is not to deny them validity. Rather, it acts as an explication of how these knowledges do not meet the scientific standard. This also entails that there are situations and contexts in which WMS is not the most appropriate form of knowledge. Furthermore and accordingly, such comparisons do not discredit the individual learner.

Therefore, as I understand it, the terms we are currently discussing are not those of “what counts” as science, but rather those of what counts best, as well as when, how, and where.

Most certainly.

However, if WMS is the only way of understanding the natural world that is recognized, perceived, or privileged as “quality science” or as best meeting its criteria, would students of non-Western cultures be required to learn WMS at the expense of their culture? Furthermore, if this is not to discredit the individual learner, could this be considered a form of epistemic violence?

As I said, this would have to be done with caution, sensitivity and care; I am not advocating for a form of science education that is inherently disrespectful. It seems that we may have
diverging notions of what respect may entail in the multicultural classroom. Let us take a step back and discuss this term of engagement.

CC: Certainly.

U: Within a multicultural classroom, there is a clear and moral imperative to treat members of all cultures justly and with respect, correct?

CC: Of course.

U: Therefore, it is imperative that all students, as well as their cultures and cultural beliefs be treated with respect as well.

CC: I agree with you up to here. Go on.

U: However, it is important to note that respecting students, as well as their cultures does not require treating their scientific beliefs as scientific knowledge. There is nothing wrong with identifying a set of beliefs as scientifically deficient, so long as it is done in a culturally sensitive manner, of course. The goal of science education is to make students scientifically literate, not indoctrinate them through scientism.

CC: You are correct in highlighting the importance of science education not simply being about teaching and upholding any belief about the natural world. As mentioned earlier, science education should certainly not become an “anything goes” form of relativism. However, this is not to say that all cultural knowledge about the natural world should simply be treated as belief. Even if the criteria for “what counts” as knowledge of the natural world is different across various cultural knowledge systems, this does not mean that TEK needs to loses its status as knowledge once it enters the science classroom. It is also worth noting that while all culturally developed systems for understanding nature are different, there are often similarities as well. For example, Gregory Cajete (1999) makes such a comparison between Indigenous science and WMS in stating: “Indigenous science is a broad category that includes everything from metaphysics to philosophy to various practical technologies practiced by Indigenous past and present” (p. 83). Similarly to WMS, Indigenous science “has models which are highly contextual to tribal experience, representational and focused on higher order thinking and understanding” (p. 85).

U: Perhaps I should rephrase my earlier statement. I do not wish to deny diverse culturally-specific knowledge about the natural world the status of knowledge. Furthermore, the degrees of similarity are in fact worth noting as many forms of ethnoscience have rich
histories of empirical naturalistic observation. However, is there not something lost in calling TEK “science?”

CC: Not always, but it is certainly a possibility that is always present. When placing multiple and diverse competing claims next to one another, there always runs the risk that they become homogenous in a way that erases their diversity and distinctiveness.

U: This is not only the case for TEK, but also WMS.

CC: I certainly agree.

U: If so, then why is calling TEK science or having it “count” as science of such importance?

CC: So long as “science” continues to be used in some educational locations as a term that excludes rather than includes, there is a need to continue working within that space even if it is complicated, complex, and sometimes contradictory.

U: I agree with you here that there continues to be science educators who deny the inclusion of any other way of knowing nature beyond WMS, but that is not what I am advocating for here.

CC: There is, however, one complexity or complication that I would like to further discuss with you when both TEK and WMS are included within a curriculum. Here, we both agree that such juxtapositions potentially affect both TEK and WMS. However, as I see it, these processes of interaction are not always even and equal in what they produce.

U: How so?

CC: Without going into a longstanding history of uneven interactions between TEK and WMS, it is nonetheless worth considering the positioning of both bodies of knowledge within the science classroom. As you mentioned earlier, you believe that it is possible to treat non-Western-modern ways of knowing nature with respect while simultaneously treating them as scientifically deficient in comparison to WMS. To me, treating TEK as less valid than WMS sends a message that is not so dissimilar from treating it as invalid. While “what counts as science” has changed to be more inclusive, this type of valuation seems to indicate that the norms through which it comes to count remain similar, if not the same. However, perhaps I do not understand your position correctly. Would you care to elaborate upon how you come to validate scientific knowledge within the science classroom?
U: Certainly. It is worth repeating here that I do not wish to deny TEK the status of knowledge about the natural world. However, this does not mean that it wholly stands up to WMS or the criteria of “quality science”. If we return to our earlier and agreed upon definition of science education as providing students opportunities to learn “quality science,” I think it is worth noting that quality is not something that varying or competing forms of knowing the natural world have or do not, but rather that some approaches are better than others. As Siegel (2001) asserts, “knowledge prized by WMS goes beyond the observational, in that it seeks … theories which are testable, and which predict and explain naturalistic observations” (p. 809). These are not only qualities attributed to the knowledge but also the knowledge building process. WMS seeks “the discovery, articulation and, explanation of regularities in nature in terms of laws which are invariably universal and invariant across time and place. This is not an assumption of universalists, but rather a methodological directive of WMS” (p. 805, emphasis in original). Do note that I am not attributing perfection to WMS as there are many contexts in which it is not the most appropriate form of knowledge such as the arts and the social sciences. However, I can confidently claim that culturally-specific understandings of nature such as TEK, as Siegel (2001) states, are “less adequate as scientific understandings than those of WMS” (p. 809, emphasis in original). While culturally-specific understandings of nature share naturalistic observation as a property with WMS, they do not achieve or produce the same quality of explanatory, testable, and predictive theories around, or towards further, observation. As such, I believe that it would be a disservice to students to not teach them primarily about the system that has reached the deepest understanding of the natural world, WMS.

CC: I agree with you that not teaching students WMS would be to do them a disservice. If you will recall, I am not arguing for the exclusion of WMS but rather for an inclusion of other ways of knowing the natural world that also takes them seriously. While I cannot fault your logic for the claim of scientific superiority that you are making for WMS when testability, predictability, and explanatory potential are the criteria, I do take issue with the criteria and how they are shaped. However, we can always come back to this as I am further preoccupied by the underlying message that you believe that such valuation can be done respectfully. Where I am unable to follow your argument is in your statement that denying a student’s
cultural knowledge the status of scientific equivalency can be done without disrespecting the student: morality and episteme go hand in hand.

U: While I agree with you that ethics and knowing go hand in hand, I do not agree with the conclusion you reach through this association. Rather, I would argue that not engaging in such comparative work would be disrespectful to students. I am making this claim on the basis that within the relationship between ethics and knowledge, there is a moral imperative to treat learners as fully rational persons or, at very least, in the process of becoming fully rational. Being fully rational means being capable of distinguishing between justified beliefs and beliefs that are either unjustified or less justifiable. Hence, providing students opportunities to exercise such rationality is to respect their capacity as learners.

CC: Granted, not treating students as capable of learning and providing opportunities for rich learning is highly problematic and disrespectful. However, being respectful of students and their ability to learn need not be at the expense of their cultural knowledges.

U: I agree here. As I mentioned earlier, providing opportunities to exercise reason need not be culturally insensitive, nor is this what I am arguing for. To learn as to why certain accounts, such as WMS, are worthy of belief is not the same as imposing knowledge or requiring the student to renounce their cultural knowledge.

CC: While we agree on not dichotomizing this issue, I believe that perhaps we are attributing different weights to the ethical valuation of respecting a student’s capacity to learn and respecting the culturally-specific scientific knowledge they bring with them into the classroom. I am not certain to which extent changing the explicit instructional message changes the implicit curricular one. As I do not see us moving forward on this at this point in time, let us return to our earlier discussion about science, education, and by extension, science education as situated learning processes. If we consider science, and hence science education, to be a situated practice, could we not include culture to the ways in which WMS’ knowledge is constructed?

U: As I have stated earlier, I do not deny the situatedness of scientific knowledge processes, nor do I deny that culture shapes scientific knowledge. As Siegel (2001) states, there is often a misconception that universalists are perceived as framing science as acultural and, accordingly, deniers of social constructivism. Rather,

universalists happily agree that scientific theories are human constructions in the sense that they are conceived, formulated, articulated, and revised by human scientists... [They] agree
that culture influences the truth claims – i.e., what is claimed at a time by scientists to be true – of science. (p. 807)

CC: Then let us reframe an aspect of this conversation. I am going to ask you to reconsider the status that WMS is granted above other ways of knowing the natural world. If we consider this to be a cultural claim, would you agree that the privileging of WMS would then be considered culturally insensitive for those who do not belong to this culture?

U: If this were strictly a cultural claim, I would have to agree, but this is certainly not the case. The privileging of WMS over other forms of understanding the natural world is not rooted in cultural presumptions or values, but rather on the criteria of “quality science”: testable, predictive, and explanatory scientific theories.

CC: Surely these criteria concerning what is considered “quality science” must also have their own cultural origins as well, mustn’t they?

U: Yes they would\(^ {49} \). However, the fact that an idea has particular cultural origins need not mean that it is true or relevant only to or within that culture.

CC: My concern here is that criteria for what counts as “quality science” are the same as those that define WMS. Furthermore, they are defined through the same set of cultural values. This circularity would lead me to believe, with WMS as the meter stick, that no other science could be considered “quality science” by virtue of it not being WMS. Would these criteria then not be self-serving, and therefore culturally presumptive as well as assimilationist when they become the basis for a “respectful” multicultural science education?

U: … but the criteria for good science are “universal” in that they are universally applicable. By this I do not mean that WMS transcends culture. Rather, if we are to take an instrumentalist approach, it is the most reliable, reproducible, and productive knowledge about the natural world. As such, it is applicable above and beyond the cultural circumstances in which it originated. For the sake of argument, even if it wasn’t, teaching WMS need not be a form of cultural imperialism. It can be taught in a manner that is culturally respectful and sensitive, there can be science education without scientism.

CC: Both of these clauses are debatable. While I believe that I have already addressed the first when I brought up the circularity of the argument, I am more concerned with the second. It has been argued that regardless of how culturally relevant, culturally responsive or culturally

\(^ {49} \) See Chapter 5 for more on the operationalization of the culture of Western modern science.
respectful science education is, if the end goal is to teach youth of WMS and bring them into its culture, it continues to be an assimilationist, marginalizing practice. Like Ali Sammel (2009),

I wonder if there is a science curricula that does not indoctrinate…. Given the pervasiveness of assimilationism in Western science education… it is not surprising that most science education includes the mandate of improving scientific literacy and then proceeds to define it, or refer to it by way of usual contemporary science education definition…. The system is pushing for assimilation of students into Western science ontology. (p. 653, emphasis in original)

It may very well be that if, as science educators, we wish to reach our earlier agreed upon goal of “providing equitable opportunities for culturally diverse students,” we may need to do so partially at the expense of what has traditionally and singularly been considered as “quality science.”

U: On this, we will have to agree to disagree. Like Charbel Niño El-Hani and Eduardo Fleury Mortimer (2007), I find myself asking:

How can we avoid demanding that our students change their beliefs by learning science, and, yet, intend that they apply in their lives what they learn in the science classroom? Surely, we could give up the second intention. But then why should we bother about teaching science at all? (p. 673)

If we need to take the “science” out of science education, then I will have no part of it. I think we are done here for today.

2.5 Act 4: Playing out the (Re)Production of Knowledge

2.5.1 When (re)signifying is signifying again rather than anew.

Like all Socratic dialogues, the above dialogue on multicultural science education produces some shared understandings but fails to reach a conclusion beyond an agreement to disagree. This disagreement is both vis-à-vis “what counts as science” as well as how one might respectfully engage multicultural science education in terms of curriculum and instruction. It could be said that this result is, in part, a function of the medium through which a mimetic production of these debates within the science education literature is filtered and inflected. Another factor is that the predominant message being presented by the literature is that the debate was and continues to be left unresolved and unresolvable. However, regardless of whether it is or is not resolvable, the Socratic

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50 Unresolvability remains nonetheless a productive feature of the multicultural science education debate: it always remains, to a certain degree, open to being otherwise (e.g., open to Indigenous science to-come). However, as knowledge is a performative enactment (see Butler, 1993, 2005, 2010), this (albeit partial) openness is contingent upon continued engagement.
dialogue implicitly acts as an invitation to engage and participate in the always already occurring play of (re)signification.

Above and beyond the dialogue between universalist and cross-culturalist characters that occurs within the play, there is also a dialogue and/or a dialectic that occurs between the reader and the text. Should you have made meaning in common (i.e., dialogically) rather than made common (i.e., dialectically), you may have located creative junctures in between the two positions that rupture and open up both sedimented scripts. However, if as a reader, you interpret the perspectives as irreconcilable, this does not mean that you have not engaged in the play of (re)signification. Rather, it may mean that the act of signification that you engaged is one that (re)plays that which is already there. In other words, through your engagement in the play of (re)signification, you have either signified again rather than anew the meanings that were already there. Recall that unmooring meaning is neither an easy nor individual affair; the “you” who (re)signifies is not only you – the language we possess also possesses us. The production of meaning is always already produced between the text and yourself, and as such, both you and the text are partially implicated in whether the meaning made was complicit and/or critical as a function of the relational flow of meaning (Derrida, 1976; Lather, 2007; Mazzei, 2007; Spivak, 1976)\(^5\).

Should you find yourself in the former position (i.e., complicit) rather than the latter (i.e., critical), it is worth considering a few key differences between the Adversary method and Socratic dialogue. While both methods rely on refuting arguments by shaking up beliefs that are held, the way they go about it and the purpose is different. Moulton (1983) elaborates that whereas the purpose of the Adversary method is to achieve epistemic victory, the goal of engagement in Socratic dialogue is to position the other party such that “they can begin philosophical inquiries with a more open mind” (p. 156). Furthermore, the success of the Socratic method depends on persuading the other person whereas the success of the Adversary method depends “on showing [the other person’s] views to be wrong to others” (p. 156). Accordingly, while the Adversary method might be an

\(^5\)Meaning-making of, or rather with texts is always a relational affair. As Spivak (1976) provocatively posits, this goes beyond deciphering the meaning intended by the author as it was never possible for a text (or for a reader or an author) to reach the status of identity (i.e., self-sameness):

two readings of the “same” book show an identity that can only be defined as a difference. The book is not repeatable in its "identity": each reading of the book produces a simulacrum of an "original" that is itself the mark of the shifting and unstable subject..., using and being used by a language that is also shifting and unstable. (p. xii)

In other words, readings are always temporary, transient, and contingent because there was never is a stable text to being with. Accordingly, readings are never singular either but rather multiplicity. This multiplicity emerges from the multiple relationships in flux that come to shape each and every reading.
effective means of proving someone wrong, it certainly is not an effective means of getting someone to agree with you.

Bohm (1996) elaborates upon this by stating that such a mode of address is a double(d) form of violence. First of all, this puts the recipient on the defensive:

The opinions that we are defending … are not merely opinions, they are not merely assumptions; they assumptions with which we are identified – which we are therefore defending, because it is as if we defending ourselves. (p. 39)

Secondly, this self-defense psychically prevents not only the reception of that which is being levied against you but also productive dialogical thought that would allow you to find common ground:

You cannot defend something without first thinking the defense. There are those thoughts which might question the thing you want to defend, and you’ve got to push them aside. That may readily involve self-deception – you will simply push aside a lot of things you would rather not accept by saying they are wrong, by distorting the issue, and so on. Thought defends its base assumptions against evidence that they may be wrong. (p. 12, emphasis in original)

Through this process, sensory and affective indicators often precede reactive thought in the form of anger, frustration, a gut feeling, a clenched jaw, a change in heart rate, or other. However, as Bohm (1996) states, you don’t always make the connection between your sensory-affective reaction, what occurred, and what you are thinking – it is incredibly common for those schooled with, in, or though Western modernity to fragment the thought from the thinker (and the mind from the body with/in the thinker) (see also Cajete, 1994, 1999). Accordingly, you use the feeling or the sensation to justify the thought, or inability thereof. In short, the Adversary method simply does not encourage others to consider that which is causing this violence, but rather a (p)re-entrenchment, a position from which defense might be possible. In turn, this makes for poor scholarly engagement if engagement is defined as something more than an individualistic endeavour.

Instead, Socratic dialogue “looks for premises that the other person will accept and that will show that the original belief was false “ (Moulton, 1983, p. 156). It is certainly worth noting here that what each and every reader might need to be convinced will be different, as well as what they might be convinced of. Similarly, but holding patterns of difference, Bohmian dialogue searches for shared meanings. This does so by asking the question “is it absolutely necessary?” (Bohm, 1996, p. 26): is it absolutely required that the other be wrong or that there be an absolute truth? For Bohm (1996), “dialogue may not be concerned directly with the truth – it may arrive at truth, but it is
concerned with meaning” (p. 43, emphasis in original). Such meaning is the type of shared meaning that emerges when assumptions and opinions are collectively opened and the play of (re)signification can occur without the need to negate previously held beliefs. Within recent literature, there have been some scholars who have been attempting to produce intermediary positions within the within the multicultural science education debate that extend (potential) points of agreement without negating firmly held claims. These dialogical possibilities yield potential for Indigenous science to-come (and are pulled through as productive insights for (re)opening the structures of science education in upcoming chapters).

2.5.2 What continues to (not) be at play? Possibilities for further dialogue through the play of (re)signification.

As it stands, the debate continues within multicultural science education literature largely around conflicting notions of “quality science” (i.e., “what counts as science”, how it is valued and evaluated) as well as questions of “quality education” (i.e., what is learned, how it is learned, questions of what constitutes respectful teaching and learning). However, a shared commitment across positions to a notion of science education that respects diverse knowers, as well as a commonly held view that it can be productive to include TEK and other non-WMS knowledges in the classroom exists, despite divergences on how these are conceptualized and enacted.

One such location is the growing consensus that students “should become scientifically literate, but not indoctrinated by scientism” (Zeyer, 2009, p. 1100). In other words, what in the past was primarily a cautionary note stemming from cross-culturalists (e.g., Lewis & Aikenhead, 2000; Sammel, 2009; Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001) is now general recognition of the possibility that science education can be and has been impositional in its nature. However, while Southerland (2000) states that one should not conflate of WMS’s claim to universalism with the impositional nature of scientism, other universalists are increasingly taking the position that it is nonetheless a possibility, and one that all science educators (regardless of their positioning within the multicultural science education debate) should be actively working against (see also Cobern &

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52 The means of knowledge production never come to fully coincide with its ends. In other words, the pursuit of truth never (fully) produces truth (Derrida, 1976). Nonetheless, while truth is always already deconstructing, deconstruction “is not the exposure of an error, it is a vigilance about the fact that we are always obliged to produce the truth” (Spivak, 1990, p. 46).

53 However, as explored in Chapters 4 and 5, universalism and scientism are not so easily disentangled. While the two should not be conflated as they are not one and the same, logics of not-the-same come to mask the workings of power without an exploration of the ways in which they express themselves through co-constitutive difference.
Despite these gains for diversity and equity, there continues to be a multiplicity of sedimented and stuck categories and concepts that represent a serious challenge to dialogical interfacing of cross-culturalist and universalist positions. Accordingly, some science education scholars have welcomed the always already extended yet implicit invitation to engage in the play of (re)signification in order to labour these meaning-full disjunctures. They have opportunistically used shared yet never fully converging meanings (e.g., the goal of science /= scientism) to labour that which continues to (not) be at play (e.g., Cobern & Loving, 2008; van Eick & Roth, 2007; El-Hani & Mortimer, 2007; McKinley & Stewart, 2010). In other words, they look to that which is conceptually absent yet present (e.g., taken-for-granted implicit and tacit meanings) as a point of differential entry instead of (or in addition to) engaging in the dialectic negation of those with whom they would disagree. For example, and explored in further depth in Chapter 4, Cobern and Loving (2008) illuminate the absent presence of ontology within the multicultural science education debate in order to justify and defend a universalist position (in turn, denouncing cross-culturalism). With these absent presences, they inflect already present terms to mean something anew and askew.

Of particular interest is van Eijck and Roth’s (2007) effort “to contribute to overcoming the multiculturalism-universalism incompatibility in science education” (p. 927) through the deconstruction of the theory/practice binary (i.e., theory as always already present within practice and vice-versa). Specifically, they invite both universalists and cross-culturalists to (mis)read knowledge as knowledge-practice. Drawing from cultural-historical activity theory and Bruno Latour’s work of reading Louis Pasteur’s discovery (of pasteurization) through Actor-Network Theory, van Eijck and Roth (2007) extend a framework in which: a) scientific knowledge derived through WMS is not only a product but also a dynamic and heterogeneous process; b) never independent of human activity such that “there is no possibility for someone to ‘have’ knowledge and simultaneously ‘fail to enact’ it” (van Eijck & Roth, 2007, p. 934); and, c) scientific knowledge is always in context such that it is both naturally and culturally situated (see also Alsop & Fawcett, 2010; Barad, 2000, 2007; van Eijck & Roth, 2009). They also signal the processual nature of scientific knowledge and the ways in it plays out in the production and application of the knowledge.

As presented in the play, both universalists and cross-culturalists agree that constructing reliable knowledge about the natural world, whether it be through WMS or TEK, is a process that is
at once culturally mediated and employs naturalistic empiricism (Aikenhead & Ogawa, 2007; Cobern & Loving, 2001, 2008; Siegel, 1997, 2001; Snively & Corsiglia, 2001). However, the processual quality of meaning making with nature is often an absent presence that upholds arguments but does not fully come to bear on the culture of the multicultural science education debate. Importantly, (re)signifying knowledge as knowledge-practice does not require either party to renounce their position; rather, it potentially opens up fruitful locations for possible dialogue.

How might considering scientific knowledge as knowledge-practice assist us in collectively working towards the shared goal of working against scientism in science education? This is significant to the overall scope of this dissertation as scientism often comes-to-be a central mechanism (alongside exclusivity and Eurocentrism; see McKinley & Stewart, 2010) through which Indigenous science is excluded, differing, and deferred. The following are three contingent insights for potentially (re)opening the spaces of science education which will come to inform the work of the chapters to come, notably that scientific knowledge-practices are: a) always situated (Chapter 3), b) culturally hybrid (Chapter 6), and c) ontologically situated (Chapters 4 and 5).

2.5.2.1 Scientific knowledge-practices as always situated.

First, as van Eijck and Roth (2007) discuss, one salient example of such an opening produced by considering scientific knowledge as knowledge-practices is around the contested status of WMS as universal. Recall that for universalists, the knowledge produced by WMS is true in all contexts, with the cautionary note that it might not be the most appropriate form of knowledge when addressing particular topics and milieus (e.g., arts, social sciences, humanities, the super-natural; Cobern & Loving, 2001, 2008; El-Hani & de Ferreira Bandeira, 2008; El-Hani & Mortimer, 2007; Zeyer, 2009). For cross-culturalists, what is at stake are the ways in which WMS is often granted epistemic privilege as a result of undiscerning translation into diverse contexts that supersedes longstanding, traditional, and complex knowledge-practices that are shaped in relation with the contexts in which they emerged (see Aikenhead & Ogawa, 2007; Aikenhead & Michell, 2011; Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001). Van Eijck and Roth (2007) diverge from these either/or positions by focusing on the when and how of universal knowledge-practice, rather than the is or is not of universal knowledge (see also Alsop & Fawcett, 2009; Haraway, 1997; Harding, 2008). In short, they focus not only on the practice of developing knowledge that can be applicable in all contexts but also what it means to apply this knowledge in a wide range of contexts: a twofold price must be paid for scientific knowledge to transcend local contexts and to become apparently static, singular, and homogeneous. First, for scientific knowledge to be produced and to be
transcendent, the local contexts to be investigated must be reduced to scientific praxis. Second, for the scientific knowledge to be applied in another local context, this target context must be transformed again to scientific praxis. (van Eijck & Roth, 2007, p. 938, emphasis in original)

In other words, they differentially articulate the cross-cultural statement that scientific knowledge-practices are decontextualized as well as the universalist one that scientific knowledge transcends context by firmly placing it within a knowledge-practice context. This context, whether real or imagined, is the scientific laboratory:

the reduction of local contexts to scientific praxis is inherent to the static, homogeneous, singular, and transcendent nature of scientific knowledge and that transcendent scientific knowledge is useless unless local contexts are changed to function like scientific laboratories. (van Eijck & Roth, 2007, p. 935)

While such conclusion may not necessarily be agreed upon by both sides as truth, it is nonetheless posits the possibility of shared meanings. For universalists, this does not require the abandonment of the notions that WMS is universal (i.e., applicable across multiple contexts) or “the best at what it does” (i.e., producing claims about nature). Treating the knowledge produced from empirical observation and Western modern scientific modes as if the context in which it were produced or applicable in were a scientific laboratory does not deny it of reliability or repeatability. Instead, it situates the conditions through which such a knowledge-practice is produced and applicable as well as the “price to be paid” for it to be so. For cross-culturalists, the situating of WMS as a knowledge-practice whose real or imagined context of production and applicability is the laboratory produces a space in which a localized TEK provides a welcome supplement to WMS that is more than the sum of what WMS is not. Because TEK is produced and produceable through a knowledge tradition that accounts for and is accountable to the ecological contexts in which they are developed, TEK’s knowledge-practices around nature are differentially produced with many of the exclusions that WMS must make to treat a context as a laboratory in mind. The “price to be paid” here is the difficulty in translating across diverse contexts. For the multicultural debate in science education here, this potentially produces a position in which the knowledge-practices of WMS and TEK might be able to share a differential yet overlapping space in which one can complement the other without the need to renounce one’s position through the situating of one’s knowledge-practice54. These shared meanings might become ripe for a (re)opening of science education for Indigenous science

54 The insight of scientific knowledge-practice as always already situated will come to inform the work of the Chapter 3. As scientific knowledge claims do not mirror reality but rather are prismatic inflections of knowledge through a real or imagined laboratory, the next chapter (re)considers optical metaphors as a location for rethinking criticality in science education.
to-come by not requiring an oppositional mode through which one side must emerge victorious.

2.5.2.2 Scientific knowledge-practices as culturally hybrid

The second possibility of working towards shared meanings with/in the multicultural science education by considering scientific knowledge as knowledge-practices debate rests in culturally hybrid knowledge-practices. Van Eijck and Roth (2009), continuing their earlier work, extend science’s internal dynamism and heterogeneity outwards by considering the complex and conflicting ways in which WMS and TEK *interact* and *interface* at the level of the personal learner in pluralistic science education contexts. This is significant as discussions within multicultural science education debate are often framed by a Western/non-Western binary that disallows the play of (re)signification between the two. It is worth attending in brief to the primary problematics engendered by the production of a fallacious Western/non-Western binary including the exclusion of conversations around the hybridity of science and the complexities of these cultural interfaces. First, the assumption that cultural traits are either separate or that they can be separated that is produced by such a binary renders invisible the many elements of WMS that stem from non-Western cultural sciences and vice-versa (e.g., the “father” of modern geometrical optics was Ibn al-Haytham, a middle-eastern man). Secondly, as these contributions are not always recognized or brought up, the historical complexities of scientific knowledge production that occur at these cultural interfaces (e.g., appropriation, assimilation) are also, accordingly, left out (e.g., the Bayer pharmaceutical company’s “discovery” and subsequent synthesis of traditional willow bark based medicine used by Indigenous peoples that is now known as Aspirin; see Snively & Corsiglia, 2000). Lastly, the Western/non-Western binary makes it difficult for science educators to account for the complexities that occur at the currently lived and differently situated cultural interfaces that both they and their students occupy (see Belczewski, 2009; van Eijck & Roth, 2009; Higgins, 2014a). However, as this binary often operates within the bounds of multicultural science education, the Socratic dialogue is written in a way that reflects it. As Indigenous science’s perpetual status of yet-to-come is invariably shaped by culturally hybrid relations in which WMS and TEK are unevenly and unequally interfaced, considering this interface as a knowledge-practice entails that it is not something that simply *is* but rather something that *is done*. As a *doing*, this invites the possibility that it might be

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55 Scientific knowledge-practice as always already being hybrid informs Chapter 6. As the ways in which hybridity is always uneven and unequal through a dialectic relationship in which Indigenous ways-of-knowing-in-being are dialectically subsumed, sublated, or sutured over, the work of Chapter 6 considers the ways in which responsibility is also shaped within this interface. In turn, this interface must be laboured it shapes the ability to respond.
done otherwise, (re)opening this oft foreclosed space of science education towards the possibility of Indigenous science to-come.

2.5.2.3 Scientific knowledge-practices as ontology situated.

The third possibility for collectively working against scientism through situating scientific knowledge-practice lies in a consideration of ontology. Cobern and Loving (2008), extending van Eijck and Roth’s (2007) notion that knowledge-practice is always culturally situated, direct attention to the ways in which epistemologies are always already ontologically situated. This is significant as the nature/culture binary, deployed within the context of the multicultural science education debate, disallows the play of (re)signification between the two (i.e., culture -> nature-culture; see also Barad, 2007). As Cobern and Loving (2008) suggest, the primary and almost exclusive focus on epistemologies within the debate has detracted from considerations of how epistemology aligns with ontology. While they use this (re)signified natural-cultural interplay to make a stronger case for universalism (e.g., “Epistemic Realism Really is Common Sense” [p. 425]), there is nonetheless room for the possibility of shared meanings. Taking seriously the notion that ontology is not a singular affair (Barad, 2007), this can be achieved not by refuting their claim but rather by situating it within a context: epistemic realism (i.e., the epistemology of WMS) really does align best with an ontology of Cartesianism (i.e., the ontology of WMS). This creates a space in which WMS achieves “distinction not privilege” (Cobern and Loving, 2008, p. 444) all the while not requiring universalists’ claims of onto-epistemic alignment to be refuted. This also produces complimentary space for differently positioned, yet also onto-epistemologically aligned, forms of TEK (see Cajete, 1994, 1999, 2000). Such plurality without negation is significant for Indigenous science to-come as the requirement for there to be a truth (read: singular) often places TEK at odds with WMS: a losing proposition when the norms of “what counts” as science best describes WMS (as “what counts” is modeled after WMS; see van Eijck & Roth, 2007).

2.6 Epilogue to (a) “Serious Play”: A Call for Further Serious Play through Dialogue

The way in which the adversary method insidiously operates within the field of multicultural science education continues to produce a space which, by paying attention to extreme positions because they are extreme,

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56 Note: Cobern and Loving’s (2008) criteria of aligning with ontology problematically treats ontology as a singular affair.

57 The insight of scientific knowledge-practice as always already being ontologically situated becomes a central notion in Chapters 4 and 5, in which Cobern and Loving’s (2008) call for ontological-epistemological alignment is both used and troubled to consider Cartesianism as but one ontology among many.
presents a distorted picture about what sorts of positions are worthy of attention, giving undo attention and publicity to positions merely because they are those of a hypothetical adversary’s and possibly ignoring positions which make more valuable or interesting claims. (Moulton, 1983, p. 158)

The resulting entrenchment of positions leads to percussive and concussive discussions that foreclose the possibility of dialoguing across difference as well as the production of positions and positional propositions in-between those presented. Or, in my case within the example at the beginning of this text, the dramatic yet almost comedic mutual (dis)engagement protected our respective terms of engagement, prohibiting the possibility of productive conversation before it even began. Such engagements often result in communication that is protective and prohibitive rather than productive (Spivak, 1976).

While the Socratic dialogue within this chapter is meant to be but an imitation of life or a form of mimesis, this mimicry of a discussion between the educators holding universalist and cross-culturalist positions acts as an invitation to the possible play of (re)signification in order to make space for dialogue and the possibility of Indigenous science to-come. In turn, questions of respect within the multicultural science education classroom need to remain open to respond to the differentially entangled values, cultures, and histories of not only students present within the classroom, but also that of science, as well as peoples to whom a curricular geo-political commitment to is made (i.e., learning about and through local Indigenous peoples’ ways-of-knowing-nature, regardless of classroom composition). Similarly, in order to keep the possibility of (re)signification of “what counts” as science open rather than foreclosed, there needs to be serious play with the assumption that non-Western bodies of scientific knowledge are not held as concurrent systems not because of their value, but how they are valued. As dialogue is about process and not product, “it’s not all that important whether you agree or not… the point is that we would establish, on another level, a kind of bond” (Bohm, 1996, p. 37). It is important to not foreclose the possibility of shared meanings (rather than “universal” truths) that are made together, and within science education, this making in common need not necessarily exclude students, both Indigenous and non-Indigenous (see van Eijck & Roth, 2009; Higgins, 2011). This is of utmost importance as not reaching shared meanings within the multicultural science education debate is of consequence for
Indigenous science to-come as it upholds a status-quo which (re)produces WMS as “what counts” best as science.\(^{58}\)

While the multicultural science education debate is characterized by an agreement to disagree, this is not to say that the dialogical movement of meaning has not occurred. On this, it is important to recognize that the nature of the debate has changed by “accepting that all systems of knowledge about nature are embedded in the context of a cultural group; that all systems are, therefore culture-laden; and that (Western) science is the system of knowledge about nature that is predominant in Western culture” (Lewis & Aikenhead, 2000, p. 3) and that even the strongest of universalists agree that multicultural science education is the direction that we should be taking in order for all students to benefit from science education. Furthermore, the three insights generated through (re)considering scientific knowledge as knowledge-practices (i.e., as always situated, as culturally hybrid, and as ontologically situated) will come to inform the work in the upcoming chapters as means of (re)opening science education towards Indigenous science to-come. However, there continues to be a need for the (re)opening of foreclosed meaning-making spaces between and across scripted positions: what counts as science within science education continues to be a necessary and significant conceptual scene for dialogical engagement, as well as a productive rather than prohibitive point of entry for (further) serious play.

\(^{58}\) The ways in which science, education, and science education have respectively operated through forms of cognitive imperialism which have had, and continue to have, real and often negative effects on Indigenous and other non-Western peoples (McKinley, 2007).
Chapter 3: Mirrors, Prisms, and Diffraction Gratings: Placing the Optics of the Critical Gaze in Science Education Under Erasure (After the Critique of Critique)

There has been in the modern Western world (dating, more or less, empirically from the 15th to the 16th centuries) a certain way of thinking, speaking and acting, a certain relationship to what one knows, to what one does, a relationship to society, to culture and also a relationship to others that we could call, let’s say, the critical attitude. (Foucault, 1997, p. 24, emphasis mine)

The purpose of this chapter is to explore what Foucault refers to as “the” critical attitude and its relationship to science education. Drawing from Foucault’s (1997) insight that the critical attitude is but a critical attitude, I explore possibilities for and of critique that stem from and respond to the crisis and critique of critique (see Barad, 2012a; Kirby, 2011; Latour, 1993, 2004a). The possibility of critique as plural is significant as the mode of critique within the multicultural science education debate from the previous chapter (re)produce Indigenous science as to-come. The adversary mode therein not only through excludes, differs, and defers Indigenous science to-come, but also upholds the metaphysics of modernity through its enactment (via distance, dichotomy as mutual exclusivity; discussed within this chapter)

Building on the insight that scientific knowledge-practice is always already situated from the previous chapter (e.g., WMS’ knowledge as contextualized within a real or imagined laboratory), I consider the ways in which criticality in science education is always mediated by conceptual apparatuses. In particular, I metaphorically employ three optical apparatus - the mirror, the prism, and the diffraction grating - to analyze and inform how the critical gaze might be re(con)figured within science education.

As critique is always in relation, I begin by positioning my own critical relation in and to science education. Secondly, I propose critical and complicit (mis)reading as the deconstructive methodological approach in the potentiality of (re)signifying science education otherwise. Third, a thumbnail account of the crisis of the critical stance (Latour, 1993) is presented with attention to

59 While not taken up in this chapter, the optical metaphors can also be thought of as analogies and articulations of the metaphysics they respectively articulate: humanism, anti-humanism, and post-humanism (see Kirby, 2011). As such, this chapter employs its own thinking as a meta-move to present entire metaphysics through their (prismatic or diffractive) articulation: the whole is in the part and the part is in the whole. Furthermore, given the adversarial nature of the multicultural science education debate (and this chapter’s critique of critique as negation), presenting optical metaphors as possibilities is meant to act as an invitation rather than present entire metaphysics and traditions through lack and deficit.

60 The expression of a “thumbnail account” is a euphemism that Apffel-Marglin (2011; see also Chapter 5) often uses that is not so dissimilar from Spivak’s (1976) treatment of “in a nutshell” (i.e., attempting to contain the uncontainable).
mirror metaphor it makes operational and the outcome for critical engagement within science education. Fourth, I explore prismatic dispersal as a first optical alternative (Butler, 2001; Foucault, 1997; Deleuze, 1988) as well as the types of critiques that can made be with/in this optics. Lastly, extending upon the prism, I investigate diffraction as metaphor that builds upon prismatic dispersal (Barad, 2007, 2012a; see also Cajete, 1994, 1999, 2000; Latour, 1993). To animate this discussion, these conceptual and metaphoric critical apparatuses are employed to ask questions anew about the multicultural science education debate (from the previous chapter).

3.1 The Subject of Critique: My Relation to Critique in/of Science Education

As a formal and informal science educator for over 10 years, I have become critical of many of the ways-of-knowing as well as the ways-of-being that govern the practices within diverse spaces of science education (e.g., Eurocentrism, whiteness, masculinism). Guided by the questions: Who is included?, Who is excluded?, and What norms shape how participation is and can be enacted?, I have begun examining the central constructs that often determine “what counts” as science within science classrooms, with a focus on Indigenous and non-Indigenous youth’s relationship to “what counts” (see Higgins, 2011). Entangled with/in this criteria for inclusion is the question of whose knowledge counts as scientific knowledge, and under which conditions it comes to be as such (Snively & Corsiglia, 2001; Stanley & Brickhouse, 1994, 2001). Digging deeper, I shifted the critical gaze to explore the ways in which Eurocentrism is entangled with/in the culture of “school science” (Higgins, 2014a; McKinley, 2000, 2007; Sammel, 2009).

While these critical explorations and enactments are fruitful in working towards decolonial goals, they also reveal the ways in which Eurocentrism circulates in capillary manners into both decolonizing processes (e.g., border crossing as pedagogy; see Aikenhead, 1997, 2001, 2006a, 2006b) and decolonizing subjects (e.g., decolonizing pedagogue; Belczewski, 2009; Higgins, 2014a; see also Sammel, 2009; McKinley, 2000). Alternately stated, despite the ways that available decolonizing curriculum and subject positions of teacher-as-researcher worked within and against a

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Here, the “thumbnail” signals that the content and issues discussed are so complex, contradictory, and convoluted that perhaps from our partial vantage points that we may never see more than a “thumbnail.” Accordingly, to give anything larger than a “thumbnail” is not only impractical, but also impossible as we are always giving an account rather than the account (see also Butler, 2005). Furthermore, it is also move towards academic modesty: giving a “thumbnail account” often requires bringing together multiple in perspectives which we can never come to know fully but without which we could not piece together an account. It is a recognition of those who precede us in making an account.

For Foucault (1977), power is not located within subjects or objects but is rather the relation between them through which power circulates.
problematic center, they were exceeded in pedagogical practice by the very (neo-)coloniality the approach challenged, thus becoming de/colonizing (see also Carter, 2004, 2010; Sammel, 2009). While there continue to be diverse, productive possible pedagogical possibilities that stem from de/colonizing approaches, not all opportunities are equally productive (see Spivak, 1988a, 1999). Accordingly, like Sammel (2009), I was beginning to “wonder if there is a science curricula that does not indoctrinate, … if there is really an authentic ‘decolonizing science practice’” (p. 653).\footnote{In 	extit{Practice Makes Practice}, Britzman (2003) cautions that: every curriculum, as a form of discourse, intones particular orientations, values and interests, and constructs visions of authority, power, and knowledge. The selected knowledge of any curriculum represents not only things to know, but a view of knowledge that implicitly defines the knower’s capacities as it legitimates the persons who deem that knowledge important. This capacity to privilege particular accounts over others is based upon relations of power. Consequently, every curriculum authorizes relations of power… (p. 39) To take Britzman seriously is to consider a curriculum that does not indoctrinate an impossibility as they are always within and in turn (re)produce particular relations of power. Within the context of decolonizing science education, this complex and contradictory space could be read as de/colonizing (Higgins, 2014a). This however, does not mean that every curriculum indoctrinates equally. Accordingly, like Lather (2007) and Spivak (1993/2009), I am interested in what possibilities become possible when we strive for the impossible (even when the very things we use and which use us are problematic). I recognize that this, in part, entails learning to differentially inhabit “the lines of making sense” which shape what is possible within “the arrangement of those lines” (Spivak, 1993/2009, p. 34).}

Critique, of that sort, could not and would not account for the multiplicity of ways in which (neo-)coloniality was always already on the move beyond and between the concepts and categories laid out for it (Spivak, 1999): it would never fit the labels of is and is not applied by critique-as-usual.

During a recent presentation that I gave on a curriculum studies panel, new possible possibilities for critique and critical engagement began to bubble. In this presentation, I discussed the taken-for-grantedness and social constructedness of conceptual norms of science education produced with/in Eurocentrism through a focus on its entangled epistemologies (e.g., epistemic realism) and ontologies (e.g., Cartesianism). During the question period, one panelist suggested that it appeared as though the ways in which I come-to-see and critique Eurocentrism was by treating it as a metaphoric “waste basket.” In other words, I was treating these constructs and systems as “prematurely naturalized objectified facts” (Latour, 2004a, p. 227). Rather than treating them in a manner that obscured their relationships as or within a complex ecology, they were all-too-simple, one-size-fits-all, pre-determined matters onto which I had passed negative judgment; they were to be disposed of and disposable. This, in turn, might make my argument easily disposable and to be disposed of: “While it may seem easy to critique Eurocentric thinking and structures, how might one ‘displace’ current thinking?” (McKinley & Aikenhead, 2005, p. 903). If this was the practice of perception that I was employing, I began to wonder if there were other ways of deploying a critical gaze that might be more productive.
3.2 The Optics of Critique: Why the Optical Configurations We (Metaphorically) Deploy Matter

The eyes have been used to signify a perverse capacity – honed to perfection in the history of science tied to militarism, capitalism, colonialism, and male supremacy – to distance the knowing subject from everybody and everything in the interests of unfettered power. (Haraway, 2001, p. 677)

Of vision, Haraway (2001) reminds us that despite the perception that we live in an age in which the plurality of technologies of sight that enhance our primate eyes are near limitless (e.g., satellite surveillance, magnetic resonance imaging, closed-circuit television, spectrometers, x-ray, radio telescopes), we never come to achieve:

a God’s eye view of the universe, the universal viewpoint, the escape from perspective, with all the rights and privileges accorded therein. Vision that goes right to the heart of the matter, unmediated sight, knowledge without end, without responsibility. (Barad, 2007, p. 233)

The “god-trick” of “seeing everything from nowhere” (Haraway, 2001, p. 678) is but an “impossible dream of plenitude” (Spivak, 1976, p. xix), an end goal never reached or reachable by its means. As “direct, devouring, generative, and unrestricted vision” (Haraway, 2001, p. 678) is but an ideology never achieved in technological practice, vision is not only always a situated and partial practice but one that must be accountable to its situatedness and partiality.

As Haraway (2001) posits, this is significant as there is a persistent metaphorical reliance on vision within critique (see also Barad, 2007; Haraway, 1997; Kirby, 2011). Even when critique metaphorically deploys vision (simply) as perspective, critique is always already a “politics of positioning” (Haraway, 2001, p. 681) in which positionings are plural, fragmented, unsteady, shifting, and on the move (Barad, 2012a; Butler, 2001; Foucault, 1997; Latour, 1993, 2004a; Kirby, 2011). However, just as “vision requires instruments of vision” (Haraway, 2001, p. 681), critique requires instruments of critique. Even normative and taken-for-granted conceptions of vision (e.g., perspective, sight) are situated and partial (e.g., location, direction), as well as supported by instruments of vision (e.g., biological technologies such as the particular eyes engaged in sight, epistemic frameworks; see Butler, 2010). Similarly, even what Foucault (1997) refers to as “the critical spirit” (emphasis mine) employs particular instruments of critique. While critique and the optical configurations that they metaphorically employ and deploy (whether implicitly or explicitly) never fully come to coincide, it is nonetheless important and productive to consider how diverse optical configurations continue to produce particular “politics of positioning” (Haraway,

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63 For example, Foucault (1997) might not self-attribute to his work the prism as an optical apparatus which informs his critique. Rather, this is an insight that is pointed out by Deleuze (1988).
2001, p. 681) within critique. Thinking with and through optical configurations can be a productive way of bringing attention to the ways in which these complex and contradictory positionings are differentially produced, framed, and (un)acknowledged. Furthermore, to think of them as configurations is an important step in working towards what Barad (2007) refers to as re(con)figurings: the ongoing processes in which configurations are dynamic, temporary, and always already being produced differentially and anew within their current agential relations.

For example, in my own critical engagement above, it could be stated that I employed an optical configuration in which “reflection [is] a pervasive trope for knowing” (Barad, 2007, p. 72). That is, I arranged constructs (e.g., “what counts as science” as a quasi-neutral cultural construct) to appear as but a false reflections of reality, while simultaneously presenting them as productions of reflections from other mirrored surfaces that I held to be true (e.g., Eurocentrism). All the while, I partially masked the mirroring process that I was engaging in, as well as the ways in which I maneuvered from one mirror to another. Accordingly, I was metaphorically positioning and utilizing the optical apparatus that shapes my critical “ways of seeing” (Haraway, 2001, p. 679, emphasis in original) such that it cast my “bad” objects into darkness and, by contrast, my “good” objects into light, making me blind to both, as well as the process itself. Through producing particular points of vantage for another reader, as well as myself, I used the “poor trick that allows critique to go on” (Latour, 2004a, p. 241): mirrors upon mirrors (Barad, 2007, 2012a).

It is not that the constructs and systems I addressed were unproblematic, or that my earlier arguments held no merit or validity. Rather, these arguments could easily be (un)done through processes of critique very similar to the ones I employed. Through slight of hand, a crafty critic could easily reconfigure the optical geometry of my argument. Obscure a little here, illuminate a little there, and a convincing reversal that exposes that which I shadowed, while shading that which I presented could be produced. Such smoke and mirrors would not resist the dialectic reversal of the very same move I was making, but my “prematurely naturalized objectified facts” would also do little to sway or engage with those whose matters of fact were oppositional to mine (see Bohm, 1996; Moulton, 1986; see also Kuokkanen, 2007; Latour, 2004a; McKinley & Aikenhead, 2005). This, of course, is without putting into question the very possibility of distance from one’s own

64 It is not that reflection and the mirrored apparatus it metaphorically employs is wrong in and of itself, but as Barad (2008) posits “the allure of representationalism may make it difficult to imagine alternatives” (p. 148). Mirroring has become so normalized that reflection has become taken-for-granted.
65 Chapter 2’s dialogue in which both the cross-cultural and universalist characters were engaged in reversing the optical configuration through dialectic is exemplary of this (e.g., both work diligently to present the other’s truth as a falsity).
matters of fact (Barad, 2007; Butler, 2001, 2005; Foucault, 1997; Kirby, 2011; Latour, 2004a; Smith, 1999/2012). It is for this reason that Latour states that “there is no sure ground even for criticism” (p. 227), and especially not for critique like that.

For this reason, it is deeply productive to engage around Foucault’s classic question of “What is critique?” (Foucault, 1997, p. 24, emphasis in original). What if the norms surrounding the critical attitude, when critiqued, revealed it to be but a critical spirit that, as Latour (2004a) states, has run out of steam? What might it mean to be critical otherwise, to engage in another critical mode that is productive rather than protective (see Derrida, 1976; Spivak, 1976)? Furthermore, if “vision requires instruments of vision” (Haraway, 2001, p. 681), how might a differential consideration and understanding of the optical apparatuses that we employ metaphorically inform and produce critically gazing (and the critical gazer) otherwise? How might an understanding of the physical phenomena of optics (e.g., properties of light within geometrical and physical optical configurations) entangled within critique re(con)figure the possible possibilities for critical engagement? If “optics is a politics of positioning” (Haraway, 2001, p. 681), how might we re-arrange the subjects and objects of vision? How might we do so without falling into the trap of going from partial and situated vision to an unsituated “seeing everything from nowhere” (Haraway, 2001, p. 678)? I was eager to explore what this might mean for decolonizing science education. In order to engage with these questions, I explore critical and complicit (mis)reading as a deconstructive approach that neither rejects the structure (as critique is still ever necessary) nor accepts it (as critique as it stands has run out of steam).

3.3 Critical and Complicit (Mis)Readings of the Optics of Critique: Science Education Under Erasure

To be at once critical and complicit methodologically is to engage in the difficult task of a double(d) reading whose “interest is in complicit practices and excessive difference” (Lather, 2007, p. 105). To unpack how I utilize the expression critical and complicit herein, it is also productive to do a

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As Spivak (1993/2009) suggests, the very act of using and troubling the very tools with which one labours against structures of dominance (e.g., critique) is of particular significance:

One of Derrida’s most scandalous contributions is to begin with what is very familiar in many radical positions and to take it with the utmost seriousness, with literal seriousness, so that it questions the position (de)constructively as the wholly intimate other. One is left with the useful yet semimournful position of the unavoidable usefulness of something that is dangerous. (p. 5)

As the tools with which resistance to dominance is laboured are at once inadequate yet necessary, to engage in deconstruction is to allow for the possibility of their reconstitution as something which does not (re)produce (or to a lesser extent) the very systems against which they are working. This is particularly relevant here as decolonizing tools are currently and constantly being appropriated and (re)purposed as means and ends for (neo-)colonialism (Smith, 2005).
double(d) reading of complicity and the promiscuously entangled ways in which they are articulated and enacted.

First, complicity signals the critical inhabitation that is required in a project of working within and against science education. Such a critical inhabitation resists both the critical rejection of the educational structure as well as the complicity that protects rather than productively engages with the problematics within it (Spivak, 1976). It is a research approach that recognizes that constructs, categories and contexts are always already rife with both problematics and possibilities at once. It is to “persistently to critique a structure that one cannot not (wish to) inhabit” (Spivak, 1993/2009, p. 284) by taking a deconstructive stance and placing this inadequate yet necessary structure under erasure. For Derrida (1976), to put something under erasure “is to write a word, cross it out, and then print both word and deletion. (Since the word is inaccurate, it is crossed out. since it is necessary, it remains legible)” (Spivak, 1976, p. xiv). Methodologically, this entails the deconstructive using and troubling of concepts, categories and constructs while recognizing that they are always already both containing and constraining while problematically and productively exceeded (Derrida, 1976; Kuokkanen, 2007; Lather, 2007; St. Pierre, 2011a). This excess gestures towards the second meaning of complicity.

Secondly, complicity signals towards the collusive relations that concepts and categories hold to their constitutive exteriority. In short, textuality is always already complicitous to its otherness (e.g. “the complicity between yes and no” [Spivak, 1976, p. 319]). Thus, being critical and complicit is not only to critique this complicity, but also a process of paying attention to the slippages in which complicities surface. However, it is not only a question of witnessing these deconstructive openings.

Thus, to place under erasure requires creative tinkering with/in those moments when the inhabited structure is self-transgressing through a two-part process. First, it entails locating a productive moment in which it reveals its undecidability. Spivak (1976) describes the process of bearing witness to undecidability as such:

If in the process of deciphering a text in the traditional way we come across a word that seems to harbor an unresolvable contradiction and by virtue of being one word is made sometimes to work in one way and sometimes in another and thus is made to point away from the absence of a unified meaning we shall catch at that word. (p. lxxv)

In short, this entails paying attention to the ways in which concepts and categories whose meanings vacillate (see Chapter 2 for the play of (re)signification) between a meaning and its constitutive otherness. This constitutive otherness can be read as a relation between binary and oppositional
terms (e.g. life/death, familiar/strange) as well as similar yet different terms (e.g. affect and effect, amoral and immoral). Secondly, it involves the prying open of this methodological fissures or locations that “harbor an unresolvable contradiction” (Spivak, 1976, p. lxxv). In short, this entails using that which exceeds it (i.e. the constitutive otherness, whether oppositional or similar yet different) as a lever by substituting it into the methodological “text”. This in turn reverses the hierarchy between intended and unintended meaning, creating the possibility for new meanings to potentially be inscribed over the trace of that which was (partially) erased (Derrida, 1976; Spivak, 1976; St. Pierre, 2011a).

Like any and every structure, there are many self-trangressive moments in which the structure both encompasses and eschews itself that provide important locations to work within and against. However, the space I put under erasure within this text is the differing and deferring space between what critique with/in science education is and is (not). The formulation of is (not) is intentional and is utilized to signal the need for “working with the resources of the old language, the language we already posses, and which possesses us” (Spivak, 1976, p. xv) while engaging in a disruptive “repetition [that] leads to a simulacrum, not to the ‘same’” (Spivak, 1976, p. lxv). In other words, it is a commitment to working within and against critique with/in science education by differentially using the concepts, constructs, and categories available by (mis)reading them through substituting similar but different iterations of the optics of critique that usually or typically frame critique with/in science education.

Critically and complicitly inhabiting this space offers rich possibilities for disrupting, displacing and differentially enacting critique with/in science education for two distinct yet interconnected reasons. First, within the context of critique with/in science education, critique, and more precisely the optics of critique presents itself as a signifier whose signified is unstable and undecidable. As explored earlier within this chapter, the optics of critique are often defined and deployed in a cursory and rapid manner (i.e., vision as semiotically pervasive but often under-defined). While optics are gestured to and enacted within many critiques with/in science education, it is not always clear as to which optics are being referred to. Rather, the meaning always differs and is deferred (see Derrida, 1976). As such, such a location presents itself as a site ripe for productive

67 Furthermore, as the signifier and signified never achieve unity (Derrida, 1976), all reading is amiss and a miss. I use (mis)reading here to signal the type of reading which intentionally utilizes the play of (re)signification as a means to leverage the space between oft-intended and more-common signified understandings and those which continue to occupy the structure of the text but hold a radical deconstructive potentiality (e.g., unintended meanings).
(mis)readings and substitutions of differential and unintended understanding of these critical optics.

Second, the disjuncture between what the optics of critique with/in science education is and is (not) offers itself as a long, and ever-lengthening lever to pry this space open while maintaining a critical inhabitation of this educational space. What the optics of critique within science education often is (i.e., the mirror) does not fully reflect the critical shifts, breaks, and developments with respect to ways-of-being-critical both theoretically and in its practical applications. However, prying open with what the optics of critique is (not) allows for a working within and against critique with/in science education that does not jettison the central metaphor of optics nor the impetus for critique that constitute it but rather considers similar yet different understandings thereof.

For Derrida, “the signifier and the signified are interchangeable” (Spivak, 1976, p. lxv). Within science education, the signifier that is the optics of critique is already in a state of undecidable signification. Thus, the task at hand herein is the rupturing of this space using the lever of signified that is what the optics of critique is (not).

3.4 Mirror upon Mirrors: Matters of Fact, Matters of Fiction, and Science Education

While the Enlightenment profited largely from the disposition of a very powerful descriptive tool, that of matters of fact, which were excellent for debunking quite a lot of beliefs, powers, and illusions, it found itself totally disarmed once matters of fact, in turn, were eaten up by the same debunking impetus. (Latour, 2004a, p. 232).

Critique has been, for the most part, a process of disrupting and displacing particularly problematic “beliefs, powers, and illusions” (Latour, 2004a, p. 232) with matters of fact. While this mode has had “prodigious efficacy” in the past, modernity’s “critical capacities are waning” (Latour, 1993, p. 35). This largely, but not exclusively, has to do with the notion that critique is all-too-often a process that is restricted to fault-finding and passing negative judgment (Barad, 2012a; Bohm, 1996; Butler, 2001; Foucault, 1997; Kirby, 2011; Latour, 1993, 2004a; Moulton, 1986). While this has been effective while operating within particular disciplinary lines, when it comes to critical engagement at the intersection of nature, culture, and politics such as is the case within cross-cultural science education, the usual critical modes of naturalization, socialization, and deconstruction begin to break down (Latour, 1993, 2004a, 2004b).

If we take seriously Latour’s (1993) eponymous thesis statement that “We [the West/Global North] Have Never Been Modern”, then the division between and mutual exclusivity of nature, culture, and politics that shape understandings and enactments of modernity never fully became actualized. In other words, even if modernity is treated as totalizing, it has never fully totalized. This
was in part because natural-cultural hybrids have been an absent presence that “moderns” have been (un)consciously relying upon since the proclaiming of nature and culture as being separate and separable. Accordingly, it is not only the more obvious points of convergence such as issues of science, technology, and society that are to be included within this entanglement, but rather that everything is *always already* within nature, culture, and politics (see also Barad, 2007; Latour, 2004b; Kirby, 2011). Thus, the entanglement of nature, culture, and politics often refuse to be explained away by such critical modes as they are always already exceeded by them (Bang & Marin, 2015; Barad, 2007, 2010; Cajete, 1994, 1999, 2000; Haraway, 1997; Kirby, 2011; Latour, 2004a, 2004b; see also Derrida, 1976). As Latour poses, “is it our fault if the intersections of nature, culture, and politics are simultaneously real, like nature, narrated, like discourse, and collective, like society?” (p. 6, emphasis in original).

The critical gazes offered by naturalization, socialization, and deconstruction are never simple or passive operationalizations of metaphoric vision (Barad, 2007; Haraway, 2001). They usually feed on the weaknesses of the other two modes in (re)presenting a truth about the world (or in the case of deconstruction, an absence of stable natural and cultural truth; see Derrida, 1976). In offering a privileged vantage point from which to state truths, naturalization states that nature *is* this by bracketing out culture, socialization states that culture *is* that by bracketing out nature, and deconstruction states that society and nature are (*not*) by denying the epistemological and ontological stability required for socialization and naturalization. These statements are respectively

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68 Within science education (Aikenhead, 2006a; Barad, 2000; Erickson, 2001), as well as within science (Barad, 2007, 2010; Latour, 1993, 2004b), the two predominant frames through which scientific phenomena are explained, explainable, and taught are those of naturalization and socialization. In other words, science education is explained through frames in which nature and culture are the predominant and respective (but not exclusive) factors through which knowledge comes to be known (see Aikenhead, 2006a; Barad, 2000, 2007; Erickson, 2001). As Barad (2007) explains, both naturalization and socialization are almost always premised within a nature/culture binary in which the constitutive other is treated as a passive surface upon which the dominant term is (re)presented (i.e., claims about Nature as complex are framed against a passive Culture; claims about Culture are framed against a passive Nature; see also Apffel-Marglin, 2011).

With respect to deconstruction’s position (see Derrida, 1976) within the space of science, Barad (2011) mentions, Invoking Derrida – the ‘poster boy’ for social constructivism gone wild (a misguided attribution if ever there was one, but so it is), the one theorist nearly everyone but deconstructionists and poststructuralists loves to use as a foil for their own supposed reasonableness, the science warriors’ darling stand-in for all that is wrong with the humanities – undercuts any pretense of a convincing straight performance. (p. 448)

In other words, because deconstruction subverts often taken-for-granted assumptions about mediated access to an external natural or cultural reality (and, more recently subverts the binary distinction between the two; see Barad, 2010, 2012; Kirby, 2011) by subverting their stability, it is often unwelcome within science or science education (Barad, 2000, 2011).

69 The parentheses here signals that deconstruction does not deny cultural or natural reality but rather denies it stability by presenting it as vacillating between *being* and *not being* within a classical epistemology and ontology (see Barad, 2010, 2012a, 2012b, 2012c; Derrida, 1976).
made at the expense of their other(ed) statements and without taking seriously the epistemic resources presented through other modes (Latour, 1993). Herein lies the major critique of critique that I will unpack here\(^{70}\), the notion that the objects under and utilized to pursue critical inquiry are attributed and granted either firm or flimsy positions but never viewed as complex entanglements that encompass both positions, across multiple critical gazes.

Through the mirror metaphor that is made operational in critique, the objects of inquiry are almost “never complicated enough” (Latour, 2004a, p. 234). They are rarely allowed to exist as objects that are the products of rich and ongoing complex natural and cultural histories, as well as produced by, and producing various participating agents (see also Barad, 2007, 2010; Cajete, 1994, 1999, 2000; Kirby, 2011). Rather, Latour (1993) suggests that the majority (i.e., roughly 90%) of the contemporary critical scene in the social sciences positions its objects of inquiry, whether they are conceptual or concrete, in one of two positions: fait (i.e., fact) or fée (i.e., fairy)\(^{71}\). In other words, they are presented as good reflections and bad reflections of reality, with the critic themselves acting as a mirror of the observed phenomena by giving a “clear” and “accurate” representation. Latour (2004a) quickly unpacks these two positions by explaining how critics too often deploy them. First, the critic presents to “naïve believers” that the object they are using and the way they are using it are but a fairy, a fantasy or fetish created through the simple projection of the critic’s wishes and desires onto the object. In other words, the first critical gesture is in re-presenting a held belief or value as but a fairy. Second, the fetishistic projection is “explained” through use of other objects of inquiry. These other objects, presented and levied as indisputable fact, defy the very possibility of the projected fairy from being an agential choice as they are given a fully causal treatment. Accordingly, the

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\(^{70}\) Within Chapter 2, I address in greater length the notion that taking an oppositional stance, what Moulton (1986) refers to as the Adversary Method, is not only an ineffective mode of getting those who would disagree with you to agree, but also acts as a dialectical move that forecloses the possibility of dialogue (Bohm, 1996; Kirby, 2011), whether literal or metaphorical.

\(^{71}\) Latour (2004a) uses fait (fact) and fée (fairy) because of their similar etymological roots. In short, both fait(fact) and fée(fairy) share a relationship to truth. Where they differ in meaning is in the type of truth that they signal: fact signals a relation to observable, and verifiable truths about the natural/physical world while fairy signals truths that are supernatural, metaphysical, and often associated with fate. For WMS, given its complex relation to the supernatural, metaphysics, and fate (e.g., the supernatural as nature’s abject other; religion, the domain of fate, as the abject other of science; see Chapter 5) as well as to truth statements that are unverifiable through empiricism, a fairy might as well be a fiction (i.e., a non-fact).

Furthermore, as explored in the next chapters (4 and 5), to decry the metaphysical as fairy in science and science education effectively masks the ways in which both are always already metaphysical (i.e., through Cartesianism; see Barad, 2000, 2007). In turn, this obscures the workings of power that occur through the enactment of this taken-for-granted and naturalized metaphysics (see Apffel-Marglin, 2011).
“naïve believer,” is twice slighted, once for investing belief in a *fairy*, and twice for not being able to perceive the *fact* that shaped them to do so in the first place.

Furthermore, critique through the mirror metaphor serves to mask the practices of positioning through which the *fact* and *fairy* labels are applied through what Barad (2007) refers to as the “illusion of givenness” that is mirrored correspondence. In short, Barad (2007) explains that the illusion of givenness that is produced through a mirroring of one’s social or natural reality begins to break down when we consider the ways in which the mirror itself is not the thing it mirrors:

As with Magritte’s famous painting *Ceci n’est pas une pipe*, the point is not that it really isn’t a pipe but only a representation of a pipe, but rather that representations do not simply refer in ways that we have come to expect, that in fact the entire question of referentiality seems to have lost its self-evident nature and givenness has lost its transparency, and we can no longer see our way through the game of smoke [and] of mirrors that representationalism has become. Like a good magician, representationalism would have us focus on what seems to be evidently given, hiding the very practices that produce the illusion of givenness. (Barad, 2007, p. 360, emphasis in original)

It is not that particular arguments can and cannot be “reflected” as *fact* and *fairy* but rather that the illusion of givenness of the mirror metaphor works to hide the ways in which such an optical apparatus was set up to produce such a reflection by presenting the carefully produced reflection as the referent.

To give an example of what is meant by the application of the mirror metaphor within critique, we will consider a dominant and contested belief that is often held within science education. As articulated in Chapter 2, how we come to understand and know nature (i.e., science) and how we use it (i.e., technology) are commonly viewed as *almost* culturally neutral processes as the result of a primarily naturalistic ontology. This configuration downplays, and often negates, the impact that culture plays in the construction and implementation of modern scientific and technological knowledge (e.g., Siegel, 1997, 2001; Matthews, 1994). A critical and/or decolonizing response necessarily must make the argument that science education is cultural in order to address the ways in which the culture of science education is damaging to Indigenous knowledges and students, as well as other students who have past and ongoing predominantly negative relationships to the (neo-)colonial culture of “school science” (McKinley, 2007; Barnhardt & Kawagley, 2005, 2008; see also Harding, 2008). Utilizing the above normative critical mode (i.e., critique) often entails, first, treating this belief as a *fairy* and presenting an oppositional claim: techno-scientific practices are

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72 This is a feature that is often identified within science education: positively by those who are proponents of science education “as usual” (e.g., Cobern and Loving, 2001, 2008) and often negatively by those who endeavour to open science education to cultural critiques (e.g., Aikenhead & Ogawa, 2007; Aikenhead & Michell, 2011).
primarily cultural and secondarily naturalistic. Second, this *fairy* is explained through *facts*: theories of Eurocentrism produce the individuals enacting this belief (e.g., Sammel, 2009). Such a critique obfuscates the possibility of diverse techno-scientific practices having diverse degrees of natural and cultural production. Perhaps more importantly, it produces a foreclosure in the very change that it advocates for: if individuals enacting this belief are already bound by systems of coloniality, how might they be otherwise? Furthermore, by presenting *fact* and *fairy*, the science education critic and the critique is either addressing those who already agree or inviting those who disagree to treat them with the same brush by reversing the *fact* and *fairy* positions to unravel the argument, as explored in further detail in the following chapter. That is, the counter-belief of techno-scientific knowledge as primarily cultural is presented as *fairy* that can be “explained” by the *fact* of an agenda of cultural politics. As Latour (2004b) states, dominant conceptions of cultural politics and nature are exclusionary by their definition, one cannot enact substantive claims about nature (i.e., scientific knowledge) from such conceptions of cultural and political positions. Thus, within a construction of science and technology as culturally neutral, such a *fact* would disqualify the counter-belief as “counting” as or in the construction of techno-scientific knowledge, thus re-inscribing science and technology as negligibly cultural (e.g., Siegel, 1997, 2001; Matthews, 1994).

Accordingly, if the culture of debate around questions of epistemic pluralism and questions of cross-culturalism within science education seems to be at a standstill, locked in ongoing dialectical reversal (Aikenhead & Ogawa, 2007; Alsop & Fawcett, 2010; Cobern & Loving, 2008; van Eijck & Roth, 2007; see Chapter 2), it is perhaps because the normative critical spirit, as Latour (2004a) playfully mentions, positions the critic and critique within an optics of appearing to be right and those with whom they disagree as seemingly wrong. This occurs in part because “there is never any crossover between the two lists of objects in the fact position and the fairy position” (p. 241, emphasis in original). On the one hand, this entails that the objects placed in the *fact* position are never explored as if they were in the *fairy* position. By treating them as strictly causal, their “origin, fabrication, [and] mode of development” (p. 238) are left unexamined. On the other hand, objects in the *fairy* position are not given the *fact* treatment. By treating them as strictly the result of a fetishistic projection, the ways in which they could continue to be causal agents, after the anti-

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73 For example, Le Grange and Aikenhead (2016) recently responded to such a claim that decolonizing scholarship operates from a “politics of resentment.” Rather, they remind that they do not refuse, refute, nor resent Western knowledge traditions: “Western knowledge should become one way of knowing and not the way of knowing” (p. 4, emphasis in original). In turn, decolonizing is not a “politics of resentment” but rather a “pursuing of cognitive justice” (p. 6).
fetishistic move is made, are masked. However, once this repertoire of critical approaches is shown to be contradictory, the “poor trick that allows critique to go on” (p. 241) begins to break down.

Engaging in questioning that reverses and disrupts the fact/fairy binary positions, the critical question of culture within cross-cultural science education begins to open up. What would it mean to consider the practice of ‘culturally quasi-neutral’ science as a fictional matter of fact? What if an exploration of its construction revealed this practice to have its own cultural and political “origin, fabrication, [and] mode of development” (Latour, 2004a, p. 238)? For example, what if the practice of ‘cultural quasi-neutrality’ was but a differential enactment of the highly political 16th century cultural practice of the “modest witness” in the laboratory? Would the practice of ‘cultural quasi-neutrality’ not then be a significant cultural practice in and of itself? Would that not also mean that this practice would disqualify it from counting in the production of techno-scientific knowledge if the criterion of negligible or trace cultural impact is infringed?

And what if the practice of ‘cultural quasi-neutrality’ is treated as a factual matter of fiction? What if a critical identification of this problematic within a culture of science education (i.e., treating it as a fetish) did not easily disallow for its rejection or did not allow for a movement beyond? If critiques that “explain” science education as a primarily cultural endeavour implicitly treat its culture as a matter of fiction rather than account for the ways in which the “cultural quasi-neutrality” is stubborn and sticky due to its own overarching systemic diffusion and self-erasure (see Barad, 2007), would the proposed solution fall into some of the same traps as the problem (see Bohm, 1996)? Does (re)presenting something as untrue halt its (re)production?

It is for this reason that Latour (2004a) states that critique, of this particular and normative kind, has run out of steam. This, of course, does not negate the ongoing importance of and need for a critical spirit around issues of inclusion, exclusion, and the norms that shape participation in science

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74 The following is a thumbnail history of the “modest witness.” In Western Europe in the 17th century, the state required a new form of governance that was not religiously partisan as the result of many years of religious wars. Turning from the church to science to keep the peace, those working within the laboratory as third party observers – the practice of the day for experimental verification – were required to abstain from pronouncing or enacting religious affiliation when engaging in the act of observation. They were to witness the experiment “modestly.” Worth considering here is that the modest witnesses were all white men of significant status, which may signal to beliefs about who was immodest “by nature” and therefore unable to participate in the cultural practice of science (see Apffel-Marglin, 2011; Haraway, 1997; Latour, 1993). For a more in-depth treatment of the “modest witness,” see Chapter 5.

75 For example, in previous research projects, I have witnessed in others and in myself an inability to simply move beyond problematic and pervasive colonial norms despite knowing about them (see Higgins, 2014a; Higgins, Madden, & Korteweg, 2015). When these norms come to constitute the possible positions one can hold, they also come to relationally bear onto the ways in which they are worked against and subverted (see next section on prismatic critique). Furthermore, as Spivak (1993/2009) reminds, “merely knowing an ideology does not dissipate its effect” (p. 5).
education. There are far too many students for whom science education remains a form of epistemic violence that threatens their ways of knowing and being with/in nature (Barnhardt & Kawagley, 2005, 2008; McKinley, 2007; Sammel, 2009). Because “the practice of critique is not reducible to arriving at judgments (and expressing them)” (Butler, 2001, p. 1) through this mode of mirror-upon-mirror, there are other metaphorical optical arrangements that are available and provide differential potential and promise.

In the following sections, I present the prism and the diffraction grating as alternative optical apparatus metaphors through which critique in science education can be (mis)read. Such substitutions act not only as a means of challenging the mirror metaphor’s implicit operations (e.g., critique as presenting what one “sees” without coming to present how one sees what they see), but also towards providing alternatives that do not outright reject the structure of critique.

3.5 Foucault’s Prismatic Critique: Proximal and Dispersive Critical Relationality

Foucault often invokes a form of the discursive, or a form of the non-discursive; but these forms neither enclose nor interiorize anything; they are 'forms of exteriority' through which either statements or visible things are dispersed. (Deleuze, 1988, p. 43)

Foucault (1997), in his talk titled *What is Critique?* implicitly rejects the mirror metaphor by problematizing its conditions. In particular, he critiques the possibility of distance between the subject and object of inquiry (see also Barad, 2007, 2010; Smith, 1999/2012). As Haraway (2001) reminds us, “the eyes have been used to signify a perverse capacity … to distance the knowing subject from everybody and everything in the interests of unfettered power” (p. 677). Significantly, this distancing is a double(d) processes that also entails separation. The distancing required for critique through an optics of mirroring makes it such that the critic can not be at once the subject and the object of one’s own critique (Barad, 2007; Bohm, 1996; Butler, 2005); it cannot and does not account for the ways in which the critique and the critic are also formed with, in, and in response to that which is under critique. This is not only important for the status of critique in general, but also critique for decolonizing purposes as well. Linda Tuhiwai Smith (1999/2012) reminds us:

One of the concepts through which Western [Modern(ist)] ideas about the individual and community, about time and space, knowledge and research, imperialism and colonialism can be drawn together is the concept of distance…. Distance again separated the individuals in power from the subjects that they governed. It was all so impersonal, rational and extremely effective. In research, the concept of distance is most important as it implies a neutrality and objectivity on behalf of the researcher. Distance is measurable. What it has come to stand for is objectivity, which is not measurable to quite the same extent. (p. 58)
Extending the earlier argument (i.e., critique as alternating flimsy and firm positions; Latour, 2004a), it can be stated that it is often the case that neither the critique nor the critic themselves are treated in the same anti-fetishistic way that the negatively judged object under inquiry is treated (i.e., the object placed in the *fairy* position). This is despite the respective importance of both the critical apparatus and the critic within the production of the optical arrangement, as well as phenomena under critique. While not discussed at length within this chapter, the oft-cited solution of placing the critic under the gaze to account for the critical production of what is seen and how it is seen often reproduces the same optical arrangement (i.e., mirror-upon-mirror), albeit differently76.

Foucault offers us the prism as a metaphoric optical technology for informing the critical gaze otherwise (see Deleuze, 1988). Rather than operationalize critique through distance and separation, as is the case with the mirror-upon-mirror arrangement, Foucaultian prismatic critique relies on subjects and objects being in porous and proximal relations. Accordingly, Foucault invites us to consider the ways in which neither the critique nor the critic are self-enclosed or interiorized, even when brought back into the critical analysis. Because of this relational proximity and porosity, subjects and objects disperse and are dispersed through the critical process. Not only does this differentially shape subjects and objects involved within the process, but also the process itself. Before addressing how prismatic critique plays out in critical cross-cultural science education, it is important to explore, outline, and situate Foucault’s (1997) conception of what critique is and can be to ground the metaphorical optical phenomena of prismatic dispersal.

As Butler (2001) states that for Foucault, “critique is always critique of some instituted practice, discourse, episteme, institution… it loses its character the moment in which it is abstracted from its operation and made to stand alone as a purely generalizable practice” (p. 1). Critique is always a critique of *something, somewhere*, and by *some one*: the norms under critique come to shape the very critique itself. This is not to say that a critical mode developed within a particular practice is a form of critical relativism that wholly rejects translation (Latour, 1993; 2004a). Rather, it is important to come to understand the qualities and conditions of that mode of critique within the

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76 Reflexivity is the often cited solution taking into account the process through which critics set up their optical apparatus, taking into account one’s own situationality (e.g., epistemology, ontology). However, it largely continues to operate through the reflective metaphor of the mirror (Barad, 2007; Haraway, 1997; Pillow, 2003). If we require an additional mirror to account for another process of reflection, then what accounts for the mirror used for accounting, another mirror? As Barad (2007) explains, “reflexivity is nothing more than iterative mimesis: even in attempts to put the investigative subject back into the picture, reflexivity does nothing more than mirror mirroring. … Mirrors upon mirrors, reflexivity entails the same old geometrical optics of reflections” (p. 88). For an example of how this plays out in de/colonizing science and technology education, see Higgins (2014a).
context in which it was developed if one endeavours to remain faithful to the intent and possibilities of critique when engaging in always already occurring process of transposing it into an elsewhere and elsewhen.

To frame prismatic critique, it is important to note that Foucault was a scholar critical of the Enlightenment. In particular, Foucault’s (1997) exploration centers the fundamental critical question characteristic of Western Europe in the 15th and 16th century of “how to govern” (p. 27, emphasis in original), and its counter-question of “how not to be governed” (p. 28) from which it cannot be disassociated. However, Foucault did not only seek to critically engage with these questions, but also engage critically with the critical process itself by seeking “to understand the kind of question that critique institutes, offering tentative ways of circumscribing its activities” (Butler, 2001, p. 2).

In his exploration of what critique is and can be around questions of governmentality, Foucault (1997) identifies three historical anchoring points. First, “critique is biblical, historically” (p. 30). As the art of governance was tied to religion, critique during that period often entailed questioning the truths that sacred texts (i.e., “the Scriptures” [p. 30]) offered, and turning them on their head to disrupt the ways in which power is maintained through these texts. Second, critique is anchored in not wanting to be governed. This resistance to governance is to address rules and laws that are unjust by putting forth irreversible and unavoidable rights to which systems of government will have to submit. Third, expanding upon not wanting to be governed, critique entails not accepting the conflation between authority and truth. This does not entail a full rejection of the truths offered by authority figures, “but rather only accepting it only if one considers valid the reasons for doing so” (Foucault, 1997, p. 31). Accordingly, as Butler (2001) states, Foucault “is not posing the possibility of radical anarchy, and that the question is not how to become radically ungovernable” (p. 6). Rather Foucault (1997) asks how “not to be governed like that, by that, in the name of those principles, with such and such an objective in mind and by means of such procedures, not like that, not for that, not by them” (p. 28). Thus, we are to be “both partner and adversary” (p. 28) to the very thing we are critiquing.

The shift from not being governed to not being governed like that is significant for two entangled reasons. First, the former is a dangerous proposition. To fully reject governability and to distance oneself from it is to risk “letting someone else say ‘obey’” (Foucault, 1997, p. 35) by

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As Spivak (1976) reminds us, every translation is always already unfaithful (i.e., never achieving sameness) due to the precariousness of intertextuality.
unavoidably stepping into other regimes of governance (see also Spivak, 1976, 1993/2009).

Secondly, Foucault (1997) presents the former as an impossibility. As Butler (2005) elaborates on Foucault’s account,

There is no “I” that can fully stand apart from the social conditions of its emergence, no “I” that is not implicated in a set of conditioning moral norms, which, being norms, have a social character that exceeds a purely personal or idiosyncratic meaning. (p. 7)

Thus, “to be governed is not only to have a form imposed upon one’s existence, but to be given the terms within which existence will and will not be possible” (Butler, 2001, p. 8). It is not only an impossibility to stand outside of the social norms that shape one’s being, but it is also an undesirability (e.g., exile, banishment; see Peat, 2002). To be fully outside the norms by which one comes to be would entail becoming wholly unintelligible as a subject and to go without the means of one’s “cultural survival” (Butler, 1990; see also Butler, 2005).

If we are always already in a proximal relation to the things that we are critical of and with, critique through a clear cut and distanced subject-object relation begins to break down, as does the mirror metaphor it makes operational. As Deleuze (1988) reminds us of Foucault, “these forms neither enclose nor interiorize anything; they are 'forms of exteriority' through which either statements or visible things are dispersed.” (p. 43, emphasis in original). The optical metaphor enacted through dispersal can be productively explored and unpacked through Foucault’s (1977) exploration of Bentham’s Panopticon in Discipline and Punish.\(^{78}\)

In short, the Panopticon is an architectural structure that works to produce the “automatic functioning of power” (Foucault, 1977, p. 201) within the disciplinary space of the prison by reconfiguring the relationship between the subject (i.e., the jailor) and object (i.e., the prisoner) of power. For readers unfamiliar with Bentham’s Panopticon, it can be described as such:

At the periphery, an annular building; at the center, a tower; this tower is pierced with wide windows that open onto the inner side of the ring; the peripheric building is divided into cells, each of which extends the whole width of the building; they have two windows, one on the inside corresponding to the windows of the tower; one on the outside allows the light to cross the cell from one end to the other (Foucault, 1977, p. 200)

Unlike the dungeon, whose purpose is also to contain and discipline by making the prisoner (socially) invisible, the Panopticon bathes the prisoners within a regime of visibility through which

\(^{78}\) While the work of Michel Foucault is relatively common within education, it is less so the case within science education (see Bazzul & Carter, forthcoming). As Latour (1993) reminds, post-structural approaches often deconstruct by illuminating the contingency and partiality of the very grounds upon which both naturalizing and socializing approaches to knowing are founded. Because these two approaches come to inform the two primary research programs within science education (i.e., cognitivism and socio-constructivism; see Aikenhead, 2006b, Erickson, 2001), they are often un-welcome (see Barad, 2000, 2011) and, accordingly, under-explored.
the jailor located within the tower can potentially see any of the prisoners, but not vice-versa. Because the jailor does not possess the ability to see everything all of the time (e.g., limited field of sight, not always being present within the tower), this uni-directional sight is important manages “to arrange things [such] that the surveillance is permanent in its effects, even if discontinuous in its action” (Foucault, 1977, p. 201). In other words, because the prisoners may not be always watched but could be watched at any point in time without their knowledge, “the inmates should be caught up in a power situation of which they are themselves to be the bearers” (Foucault, 1977, p. 201).

Here, it is no longer appropriate to state that the governmentality that Foucault is so critical of (and in relation to) is located strictly within the jailor who is traditionally conceived of as the contact point of power when thinking about the dungeon. Furthermore, while it can be said that the prisoners in this context practice self-discipline by inscribing “in [themselves] the power relation in which [they] simultaneously plays both roles [i.e., jailor and prisoner]” (Foucault, 1977, pp. 202-203), this is not to say that they have internalized and contain the discourse of power. Rather, the architecture acts as an apparatus which places them all in proximal relation through which disciplinary power and knowledge circulate in a capillary manner, dispersing through and simultaneously (re)producing them as subjects and objects of knowledge. As Butler (1990) states of Foucault, “systems of power produce the subjects they subsequently come to represent” (p. 2, emphasis in original). These structures cause subjects to be “formed, defined, and reproduced in accordance with the norms of those structures” (p. 2). In his critique of governmentality through disciplinary forms of punishment, Foucault turns the “sacred text” of power as individualistic and repressive (i.e., a Marxist conception of power) on its head: disciplinary power circulates through nodes (i.e., subjects and objects) and is productive (e.g., produces and organizes subjects as well as objects)\textsuperscript{79}. Subjects do not unequally have access to power; rather they are unevenly had by power.

The relation to critique and the point to be made here is not that critics and their critiques are always already under a regime of visibility through which disciplinary power flows in exactly the same ways as in the example of an incarcerated prisoner. Rather, “the Panopticon…must be understood as a generalizable model of functioning; a way of defining power [and knowledge] relations in terms of the everyday life of men [sic]” (Foucault, 1977, p. 205). With respect to critique, panopticonism is useful to think about the ways in which both the subject enacting critique

\textsuperscript{79}Spivak (1988a) offers an important cautionary note on this subject. If for Foucault, power circulates through all nodes, and that accordingly, resistance to power can happen at any node, Spivak reminds us that power however does not circulate evenly; while resistance can happen anywhere, some locations are nonetheless more significant than others.

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(i.e., the critic) and the objects of critique are within a proximal relation through they are differentially produced and organized. It is useful to think about the Panopticon as metaphor for disciplinary power and the ways it circulates not only as a governmental mode of punishment, but more broadly as the ways in which disciplinary knowledge (e.g., science, education) disperse through, produce, and organize subjects and objects of critique. Disciplinary knowledge is a productive double(d) meaning as it need not only be read as the knowledge content of a discipline. It can also be read as the ways in which knowledge is disciplined. Disciplinary subjects (i.e., both the curricular content and those conveying the content) are produced (i.e., within norms) through the operationalization as well as the possible application of panoptic disciplinary power.

As presented by Butler (2001), Foucault argues “critique will be dependent upon its objects, but its objects will in turn define the very meaning of critique” (p. 3). This is doubly important. First, this necessarily entails giving the objects of critique a more robust treatment than the matters of fact and matters of fiction that Latour (2004) cautions against as too simple a framing will result in too simple a critique. Second, the very objects of critique also produce particular possibilities and positions for the “subjects” of critique, through subjectification of the critics themselves. In other words, the critic does not come to critique with a stable subject position/ality prior to the act of critique (i.e., being) but rather the very norms which they are critiquing shape the position(s) which they can take in relation to those norms (i.e., becoming) (see Butler, 2001). The very norms that organize what is a matter of fact and what is a matter of fiction produce (and are produced by) the critic and the epistemological context (i.e., what and how the critique can know) within which they are operating.

With Foucault’s prism as an optical prosthetic technology, the task of critique becomes not one of establishing or employing a “pregiven epistemological context” (Butler, 2001). Rather, critique is about exposing the limits of the epistemological context. In turn, recognizing the limitations of an epistemological context entails accounting for and being accountable to the relationship between the subject and objects of critique through which the context emerges. Thus critique, for Foucault (1997), is “the art of voluntary insubordination, that of reflected intractability” (p. 32) through which the critic engages in a “practice that not only suspends judgment, … but offers a new practice of values based on that very suspension” (Butler, 2001, p. 1). This suspension is critical in both senses of the word because it asks how the very judgments we make as critical subjects are already produced and organized within the proximal and prismatic relations between
our/selves as critics and the objects of critique we glorify and dismay (see also Bohm, 1996). If we engage in critique as “the movement by which the subject gives himself the right to question the truth on its effects of power and question power on its discourses of truth” (Foucault, 1997, p. 32), would we still arrive at or care to make the same judgments altogether?

Returning to the question of “what counts” as science within the context of cross-cultural science education (from Chapter 2), considering critique as prismatic opens up additional lines of questioning that can be engaged critically. While questioning might open up new lines of critical engagement, recall that questions that reveal the epistemological limitations and shape (i.e., the lines delineating the interiority and exteriority of truth) of a particular epistemic framework are for Foucault a form of critique in and of themselves. Rather than engaging in acts of judgment through which objects of critique are positioned as either matters of fact or matters of fiction, Foucault’s prismatic critique invites us to consider the relationships through which these judgments are produced through optical inflection. If we revisit the earlier question regarding the matter of science education as ‘culturally quasi-neutral,’ rather than immediately framing this as good/true (i.e., a matter of fact) or bad/false (i.e., a matter of fiction), it is worth momentarily suspending judgment to ask how critique is formed with/in relation to these norms.

If we treat science as ‘culturally quasi-neutral’ as a point of illumination, through what categories, constructs, and concepts is meaning dispersed and inflected to produce this constellation of meaning? What are the critical objects that are utilized to either uphold or question this norm? What objects are positioned as abject (e.g., how does “culture” come to be seen as problematic?) and which ones are positioned as positive levers (e.g., how does method come in to stand for and as quasi-neutrality)? What optical geometries are required for these to come to be, and to be sustained as such?

Recognizing that the light/prism relationship is often interchangeable, how is it that ‘cultural quasi-neutrality’ dispenses and inflects its negative and positive objects? Treating ‘cultural quasi-neutrality’ prismatically also invites the question of what it produces in turn when meaning is inflected through it. For example, how is it that practices deemed cultural (rather than quasi-neutral) are inflected in terms of their meaning when shone through that prism? What about sanctioned scientific methods?

What about questions of curriculum and pedagogy? When science education is filtered through the normative prism of ‘cultural quasi-neutrality’, what kinds of pedagogies and curriculum
are dispersed and inflected through the other side? Which ways of learning and ways of knowing are (re)produced? What is made possible and made impossible (e.g., What conceptions of a learner can and do emerge when cultural quasi-neutrality is part of the illumination)? What kinds of learners and learnings as well as teachers and teachings are made intelligible/unintelligible within this space?

Expanding upon the last question, how are the critics themselves, as the subjects of critique, formed with/in theses multiple relationships that often appear to be epistemologically pre-given? How are the critics inflecting this vector of light not like that (e.g., What facets of the optical arrangement are being deflected, inflected, inverted, and redirected; which meanings are flow through, with minor refraction at most?)? How do these inflections shape the critic whose self is in prismatic relation to them (e.g., as critics, as educators, as researchers)? When considering the ever increasing ways in which the cross-cultural science education classroom is presented with plural(istic) ways-of-knowing-nature, processes and products that exceed the norms by which we frame science and by which we are framed as science educators, it becomes important to consider the rich luminescent web of dispersed meanings when thinking about what is (im)possible within/as science education.

3.6 Baradian Diffraction: Including the Critical Apparatus in the Production of Critique

It is a well-recognized fact of physical optics that if one looks closely at an “edge,” what one sees is not a sharp boundary between light and dark but rather a series of light and dark bands – that is a diffraction pattern. (Barad, 207, p. 156)

While Barad (2007) does not explicitly make the act of critique a focus of her scholarship in Meeting the Universe Halfway, she does speak to critique in a recent interview:

Critique is over-rated, over-emphasized, and over-utilized... Critique is all too often not a deconstructive practice, that is, a practice of reading for the constitutive exclusions of those ideas we can not do without, but a destructive practice meant to dismiss, to turn aside, to put someone or something down. This is a practice of negativity that I think is about subtraction, distancing and othering. (Barad, 2012a, p. 49)

Like Foucault (1997), Barad (2012a) is critical of distance and separation as the (pre-)condition under which the critical spirit operates. The othering of the object of critique obscures the ways in which the subject of critique is indebted to its other through its proximal and co-constitutive relationship (see also Barad, 2007, 2010); not only epistemologically, but also ethically and ontologically. For Barad (2007), such critique cannot be disassociated from “long history of using vision and optical metaphor[s] to talk and theorize about knowledge” (p. 29), particularly the “well-worn metaphor of reflection” (p. 29). For her, the common-place understanding of reflection can be understood as such:
Mirrors reflect. To mirror something is to provide an accurate image or representation that faithfully copies that which is being mirrored. Hence mirrors are an often-used metaphor for representationalism and related questions of reflexivity. For example, a scientific realist believes that scientific knowledge accurately reflects physical reality, whereas a strong social constructivist would argue that knowledge is more accurately understood as a reflection of culture, rather than nature (p. 86).

For Barad (2007), the act of reflection is about mirroring sameness elsewhere. As mentioned earlier within this chapter, this largely has to do with the ways in which the mirror metaphor produces an illusion of givenness through which claims of correspondence are masked. Thus, through reflection, patterns of difference are dialectically subsumed into or sublated through sameness, making it difficult to account for and be accountable to the enactment of difference (see Chapter 2). As an alternative to reflection, Barad (2007, 2012a) proposes diffraction as optical metaphor that attends to relations of difference, and how they are differentially done and undone. In a nutshell, “diffraction involves reading insights through one another in a way that help illuminate differences as they emerge: how differences get made, what gets excluded, and how those exclusions matter” (Barad, 2007, p. 30).

Here, a rich possibility is offered through the metaphorical optical alternative proposed for cross-cultural and decolonizing science education. Given that cross-cultural science education endeavours to make space for ways-of-knowing-in-being that are not typically included within the curricular scope, the invitation to consider otherness without the necessity of bringing it into frames of sameness and/or being accountable to that which is exceeded by frames of sameness when applied is of importance. Too often other(ed) ways-of-knowing-in-being (e.g., Indigenous) are placed in a relationship that dialectically reduces their elements to those that they share with dominant WMS, at the expense of their uniqueness and possibilities (e.g., ethics, balance, other-than-human agency; Cajete, 1994, 1999, 2000). Furthermore, while the intent is not new, the practice of diffractive critique can bring new ways to account for and be accountable to relations of power between normative and alternative ways-of-living-with/in-nature.

However, if we continue the work of labouring the metaphor of visuality and technologies of sight with respect to critique, before applying the optical metaphor of diffraction, it is important to have an understanding of the optical referent to which it refers. In short, Barad’s metaphor of diffraction invites a more nuanced and complex understanding of the natural phenomena informing

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80 I take the time to unpack the concept of diffraction here as the impact of Karen Barad’s work and inter-related web of concepts (e.g., intra-action) is only recently coming to bear on educational theory and practice (e.g., Lenz-Taguchi, 2010), and even more recently within science education (e.g., Scantlebury & Milne, forthcoming).
this referent: light. As Barad (2007) reminds us, the optical mode through which most critique operates is Euclidian (i.e., rectilinear). However, light does not always act linearly: “under certain experimental circumstances, light manifests particle-like properties [i.e., enacting Euclidian geometries], and under an experimentally incompatible set of circumstances, light manifests wave-like properties [i.e., enacting non-Euclidian geometries]” (Barad, 2000, p. 233). Accordingly, this is not an invitation to strictly consider light, and according mediated visualities as non-linear, as they are still produced as linear under particular experimental circumstances. Rather, it is an invitation to consider light and properties of mediated vision interacting as both particle and wave-like properties, as well as consider the conditions under which they become particle and wave-like. To do so, Barad (2007) introduces the physical phenomena of diffraction as a useful in exploring this referent.

Before considering light as both wave and particle as a metaphorical referent for the practice of critique, it is worth quickly unpacking what it means to consider light as demonstrating wave properties before moving forward. Within classical physics, this phenomena is called *diffraction*, and it “has to do with the way waves combine when they overlap and the apparent bending and spreading of waves that occurs when waves encounter an obstruction” (Barad, 2007, p. 74). While some physicists hold to a history in which the first phenomena (i.e., combining of waves) are referred to as *interference*, Barad (2007) reminds us that both phenomena have to do with the juxtaposition of waves. Since it is classically a property of all waves, I will give examples of both types of classical diffractions with wave phenomena that might be more familiar: sound.

To demonstrate the first definition, imagine that you are at an outdoor (soft) rock concert with two loud speakers at each end of the stage. Should you have the freedom to walk about the area, you may come to find that there are spaces where the music seems quieter, as well as spaces where the music seems louder. This has to do with the principle of wave superposition that states that when waves occupy the same position or immediate local space, their amplitudes combine to create a new wave. This new wave may be dampened through destructive interference (i.e., when the waves’ amplitudes are opposite) or intensified through productive interference (i.e., when the waves’ amplitudes align).

For the second instance, imagine that you are speaking into a cardboard tube. The sound that emerges from the other end does not follow the linearity of the tube, but rather spreads out. This second type for diffraction occurs when waves encounter a slit, a hole, or an obstacle whose wavelength is no greater than their own (e.g., sending light waves through the same cardboard tube.
would not produce any noticeable ripples). While the tube prevents the sound to exit it anywhere but the opening, each and every point along a wave can and does act as a point of origin which explains why it seems like the sound wave bends in all directions once exiting the tube.

However, recall that Barad (2000, 2007) invites us to consider light as both wave and particle. This requires us to explore diffraction as a quantum phenomenon. Here, it is productive to discuss the experiment that is emblematic of the collapse of classical Western metaphysics: the two-slit experiment. In this experiment, a single particle, such as an electron is fired into the two-slit experimental apparatus that is configured to observe wave phenomena. This is significant as within classical physics, particles are largely thought to behave like other forms of matter, in mechanistic, causal, and linear manners; that unlike waves, particles as material phenomena entails spatial single occupancy (unlike the wave superposition discussed earlier). Were this simply the case, this experimental apparatus would have yielded no observation and would have been largely forgettable. However, produced through this experiment were diffraction patterns that indicate that under the right experimental conditions, particles exhibit the behaviour of waves. It is also worth noting that the corollary would also be shown to be possible as well in doing similar experiments with light waves and creating experimental conditions in which they would behave as particles. This is of deep importance as these materialities (i.e., waves and particles) exhibit and enact properties that are ontologically mutually exclusive within classical physics.

From this, a few theorists offered theories to attempt to explain this wave-particle duality. Of note is Heisenberg’s uncertainty principle that posits the wave-particle duality as epistemological, as a limitation to knowability. However, Neils Bohr’s theorizing, which is the commonly accepted theory, states that this duality is of ontological nature. The phenomena is not simply presenting itself again by representing its essence, but rather, the experimental conditions under which observation occur shape the properties of what the phenomena can be.

Working with physicist Neils Bohr’s journals, Barad extends his analysis by asking where the agencies of observation begin and where they end, what is included, what is excluded, what matters, and what comes to materialize. While Barad originally draws from Bohr’s work to theorize materiality and materialization within the context of quantum physics, she later extends these
conclusions outwards. The role, the constitution, and the enactment of the apparatus is an important location where Barad’s work specifically deviates from and inflects Foucault’s. However, this deviation is not one of critical negation, sublation, or subsuming (by reducing her objects of critique to matters of fact or matters of critique), but rather a diffractive reading. Recall that for Foucault (1977), apparatus such as the Panopticon are at once physical, discursive, and organizational structures, which are produced by and reproduce the capillary workings of power within society. As Barad (2007) states, “although Foucault insists that the objects (subjects) of knowledge do not pre-exist but emerge only within discursive practices, he does not explicitly analyze the inseparability of apparatuses and the objects (subjects)” (p. 201). In other words, while Foucault considers the ways in which apparatuses of power such as the Panopticon produces phenomena of subjectification, Barad (2007) invites a consideration of how the phenomena of subjectification comes to produce apparatuses such as Panopticon.

Through a diffractive reading in which she reads Bohr’s insights through Foucault’s, and vice-versa, Barad (2007) produces new insights. In particular, she reads Foucault’s insights into societal phenomena with Bohr to postulates that the apparatus not only produces the phenomena under observation but also that the apparatus is constitutive of and constituted by the phenomena as well. Thus, if for Foucault subjectivity is not contained by the subject through interiority but rather a generative enactment in relation to the norms which govern the possible possibilities of who and what one can be (see Deleuze, 1988), Barad extends this theorizing to the apparatus as well.

Asking the question of what constitutes “an apparatus” that comes to produce and be produced by a phenomena, she reaches the conclusion that an apparatus is observed is never simply a material tool or a discursive concept through which the phenomena can be observed, but rather an entangled and enacted network of agencies at play. One example of such that Barad (2007) provides is that of the Stern-Gerlach experiment in 1922 in which Otto Stern and Walther Gerlach

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81 For Barad (2007), materialization is a complex, non-linear, and dis/continuous phenomena through which space, time, matter, and meaning are differentially enfolded. In other words, it is an ongoing process through which everything comes to bear and comes to be, in which the co-constituting parts do not come to act in an equal or even manner.

82 Barad (2007) invites us here to differentially consider the relation between the literal or metaphorical observer, the apparatus of observation, and the observed phenomena, not by collapsing them into one, but by considering them as co-producing and inseparable. Since “apparatuses are themselves phenomena” (Barad, 2003, p. 816), even metaphorical apparatus that are the tools of critique come to produce and be produced by the subject of critique (i.e., the critic) and the object of critique.

83 While beyond the scope of this paper, Barad (2007) proposes that while the panopticon may be exemplary of observational technologies of the 18th century, Barad proposes ultrasound technology as a more contemporary example of an apparatus of observation that is produced by and producing the phenomena it is meant to observe.
experimentally and empirically made demonstrable the theoretical concept of “space quantization.” This phenomena in which electrons made quantum leaps from one discrete orbital or energy level to another within an atom was well developed within theoretical atomic models, however, classical understandings of atomic configurations were reluctantly held onto until proof of some sort was given to justify the theory (or debunk the theory as a temporary stand in for another misunderstood phenomena). However, Stern and Gerlach created an instrument that, “using a particular arrangement of magnets” (p. 163), would show the ways in which a beam of silver atoms’ electrons are differentially positioned, oriented, and configured within an atom through deflection: some would be deflected upwards and some would be deflected downwards. As Otto Stern recounts the experimental event,

With Gerlach looking over my shoulder as I peered closely at the plate, we were surprised to see gradually emerge the trace of the beam... Finally we realized what [had happened]. I was the equivalent of an assistant professor. My salary was too low to afford good cigars, so I smoked bad cigars. These had a lot of sulfur in them, so my breath on the plate turned the silver into silver sulfide, which is jet black, so easily visible. It was like developing a photographic film. (Otto Stern in Barad, 2007, p. 164)

The experiment functioned. What Barad makes clear is that the very boundaries that constitute the apparatus through which phenomena stabilize and make themselves intelligible are not so easily determined, or at least enclosed within that which is usually referred to as “equipment” within a laboratory report. Here, when asking the question of what constitutes the apparatus through which the phenomena was enacted, we would necessarily have to consider not only the material agency of the cigar, but also questions of gender, class, and economics through which that particular type of cigar came to be included. As Barad (2007) cautions, this “is not to say that all relevant factors figure in the same way or with the same weight. The precise nature of this configuration (i.e., the specific practices) matters” (p. 167). Accordingly, “apparatuses are not static laboratory setups but a dynamic set of open-ended practices, iteratively refined and reconfigured.” (p. 167). The apparatus is the enactment of a singular multiplicity that enfolds multiple bodies of meaning and matter that comprises each of their respective material and discursive historicities. As such, these constitutive bodies do not simply inter-act between one another, but rather intra-act within this re(con)figured body which is the experimental apparatus. Barad refers to this type of co-substantiation that occurs with/in the apparatus, as well as the phenomena under observation, as one of quantum entanglement.

Quantum entanglements are generalized quantum superpositions, more than one, no more than one, impossible to count. They are far more ghostly than the colloquial sense of ‘entanglement’ suggests. Quantum entanglements are not the intertwining of two (or more) states/entities/events, but a calling into question of the very nature of two-ness, and ultimately of one-ness as well. Duality, unity,
multiplicity, being are undone. ‘Between’ will never be the same. One is too few, two is too many. No wonder quantum entanglements defy commonsense notions of communication ‘between’ entities ‘separated’ by arbitrarily large spaces and times. Quantum entanglements require/inspire a new sense of a-count-ability, a new arithmetic, a new calculus of response-ability. (Barad, 2010, p. 251, emphasis in original)

Returning to the question of what critique is and can be, Barad’s (2007) notion of diffraction invites us to consider the ways in which the very process of critique differentially produces the subject who critiques alongside the object(s) of critique (as does Foucault). Uniquely, she also invites us to consider the ways in which the norms of bodily production through which these subjects and objects come into being through the enactment of critique are not being pre-given. Just as Foucault’s critique invites us to trouble the notion of an epistemological pre-givenness of the terms through which the critique operates, Barad invites us to trouble an ontological pre-givenness of the ways in which the usual subjects and objects of critique are segmented and separated. It is a call to consider them as superpositioned without the form of “a-count-ability” being one in which superposition entails sameness (i.e., one-ness) or radical differentiation (i.e., two-ness); it is a form of a-count-ability that accounts for its own ontological cuts as well as the norms of inclusion/exclusion that are shaped through this practice.

Along similar lines, Latour (2004a) states that:

The mistake we made, … was to believe that there was no efficient way to criticize matters of fact except by moving away from them and directing one’s attention toward the conditions that made them possible. But this meant accepting much too uncritically what matters of fact were (p. 231, emphasis in original)

Latour (2004a), like Barad, reminds us here that critique need not only be about the taking apart of constructs, constraints, and consequences of particular matters of fact or matters of fiction. As these are always already the product of entanglements which are enacted, there is always the possibility of the very things that matter to us from being enacted in such a way that the very entanglement is re(con)figured to be a product of hegemony. If the very things we care for are constructed, it means that we are to operate with care in how we (re)enact them.

Critique as diffraction is then a process of producing, and being responsive and accountable to non-negligible patterns of difference that come to matter when two (or more) entangled material-discursive phenomena are diffracted through one another. This requires however that “we learn to

\[^{84}\text{Similarly (but not identically), Bohm (1994) also resists the mirror metaphor of sameness and its constitutive other of pure difference by speaking to similar differences and different similarities. These similar differences and different similarities are concepts used to talk about the relations that are always already constitutive of an undivided whole(ness), as well as the impossibility of achieving the total separation required for pure sameness or difference to be achieved.}\]
tune our analytical instruments (that is our diffractive instruments) in a way that is sufficiently attentive to the details of the phenomenon we want to understand” (p. 73) and to pay attention to the fine details that would otherwise be considered negligible with/in conventional scientific and social scientific research methods.

Let us return to the question of “what counts” as science within the context of cross-cultural science education and the dominant assumption of scientific knowledge’s “cultural quasi-neutrality” (from Chapter 2). Recall that like Foucault’s prismatic critique, Barad’s diffraction questions the \( a \text{ priori } \) status of epistemology (e.g., concepts, constructs, and categories). However, the dispersal, deferral, and displacement of culture through discourse is further troubled by questioning the \( a \text{ priori } \) status of ontology (e.g., space, time, matter). This entails that the ontological units onto which critical arguments are mapped are not passive (e.g., time \( \rightarrow \) causality) but rather are enacted, as are the cuts by which these units come to be. Furthermore, in considering ontology as dynamic, Barad (2010) invites a reconsideration of its dualistic or dichotomized relation to epistemology; “one is too few, two is too many” (p. 251). Accordingly, culture is not only “internally” co-substantiated through superposition, but its “exteriority” (i.e., nature) is active and agentic with/in this entanglement: everything is within culture; everything is within nature (see also Latour, 1993; Kirby, 2011).

So, what does this mean for science and science education if the dominant belief that nature produces the ‘quasi-neutral’ cultural mediations that are scientific knowledge? The lines of questioning shift from asking whether WMS is or is not a (sub-)culture and cultural production (i.e., \textit{matters of fact} and \textit{matters of fiction}), as well as how cultural meanings are inflected and dispersed through one another to produce a normative web. If everything is within culture and nature in their totality, and the two are co-substantiated rather than dualistic or monistic, then \textit{everything} comes to bear in the production of Western modern scientific knowledge. To what degree do the multiple natural-cultural agents participate in the production of phenomena under observation? What ways-of-knowing, ways-of-being, or perhaps more appropriately, ways-of-knowing-in-being are enacted through such entanglements?

If we consider the ways in which the part is within the whole (see Barad, 2007; Cajete, 1994, 1999, 2000; Peat, 2002), when scientific knowledge derived from WMS is brought into the science classroom, what is produced through such diffraction? What comes to matter (and to what degree)? How do the ways-of-knowing-in-being enacted within the laboratory by scientists, technological
apparatus, and by agentic matter intra-act within pedagogical entanglements with students (and other natural-cultural agents within schools) when they too are considered as a part within the whole? What occurs when other ways-of-knowing-in-being are diffracted through these normative entanglements? If entanglement does not equate equality, sameness, or uniformity, what are the patterns of difference that occur with/in? What types of negotiations, navigations, and hybrids are (im)possible?

Also, if we consider WMS to always be an enactment of knowing with nature rather than about nature (i.e., matter comes to matter within experimental conditions), what is entangled within the production that frames it to be knowing about? Furthermore, if knowing is always already knowing with nature if everything is always within nature, how might we engage in the multiple possible possibilities of knowing with nature without slipping into relativism? What are some of the systems and approaches that shape WMS and its relation with/in nature? What are other systematic and sustained engagements of learning with nature and what can be learned from/with these enactments? What can be learned from practices of a-count-ability already frame them as ways of learning with and from nature (rather than about; e.g., quantum physics, IWLN)? Lastly, if different ways-of-knowing-with-nature produce differently entangled possible possibilities, what might be desirable goals for science education?

3.7 Conclusion: Re(con)figuring Critique in Science Education

What would critique do if it could be associated with more, not with less, with multiplication, not subtraction? (Latour, 2004a, p. 237, emphasis in original)

For scholars critical engaging at the intersections of science and society (e.g., science education), critical resistance to scientific normalization through modes of exposing that “there is no such thing as natural, unmediated, unbiased access to truth, that we are always prisoners of language, that we always speak from a particular standpoint” (Latour, 2004a, p. 227) have, in the past, efficiently worked against problematic “ideological arguments posturing as matters of fact” (p. 227). However, these modes of critique have become the very tools working against critics. In other words, the very tools of dismantling a normative center have been absorbed by the center and have been

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85 For me, attempts in identifying science as socially constructed through Eurocentric norms have resulted in having the same logic returned my way: through pointing out that my position too was constructed (in a society in which construction equals fabrication). In other words, opponents would receive my jabs at universalism and return them to slide debate into relativism, reversing the binary bring the possibility of critique to a standstill (see Latour, 1993, 2004a; Haraway, 2001). Chapter 2 is an example of how these logics permeate the multicultural science education debate, unproductively.
redeployed against the margins: the argument that the dominant position is but a situated and partial position is, through metaphoric substraction, being applied to those who critique the norms of science. As the critical gaze is never a passive operationalization of visual metaphors (Haraway, 2001), to posit a geometric arrangement is to also put forth the very terms through which your argument can be reversed, deflected, and diverted (see also Barad, 2007).

As an emerging de/colonizing science education scholar and practitioner, my primary focus is on Indigenous science to-come: critically engaging with (re)opening the structures and strategies of science education so that Indigenous science might be other than excluded, differing, and deferred. My critical engagements with/in pedagogical practices had me slowly becoming worried about critical possibilities and the possibilities of critique (see McKinley & Aikenhead, 2005); particularly if decolonization would always be de/colonizing (i.e., always shaped in response to and slipping back into colonialism; see Carter, 2004, 2010; Higgins, 2014a). Critiques through an optical geometry of matters of fact and matters of fiction, could not fully contain the ways in which one would flow into the other. When considered in tandem with an invitation to not treat one’s negative objects of critique as one-dimensional and through a (never fully achievable) process of negation, I began asking if the issue at hand was not critique, but rather norms around critique which would make it appear as if there is (only) a way of being critical.

In this chapter, I explore three optical technologies which metaphorically inform, shape, and (re)produce ways of being critical: namely the mirror, the prism, and the diffraction grating. While all three modes hold differential potential and promise, and the intent herein is not to prescribe one critical metaphor at the expense of another, Latour (2004a) invites us to consider the ways in which the mirror metaphor may simply have “run out of steam.” While there are moments in which politically posturing as mirroring the truth is productive and of deep importance, it is nonetheless important to consider and confound what the metaphor makes operational86. By placing its objects of critique in either a fact or fiction position, the mirroring critique and critic becomes blind to the ways in which the matters of fact are fictional as well as how matters of fiction are factual. The critique itself then is not only easily taken apart by others who may not share the same point of view, but it is also always already self-rupturing through its persistent yet productive failure of containment.

86 Spivak (1993/2009) refers to this practice as “strategic essentialism”: an critical inhabitation of truth-telling and representation through essentialism that works relentlessly to undo its own essentializing. See Chapter 5 for further discussion and use thereof.
The prism, informed by Foucault’s theorizing of critique, is not about displacing sameness elsewhere through mirroring. Rather it is an invitation to consider the ways in which the subjects and objects of critique are dispersed through one another and, in turn, produce one another, albeit differently. Within cross-cultural science education, this was explored around questions surrounding claims of “cultural quasi-neutrality” which shape dominant approach not as something that is or is not (i.e., achieving epistemic a priori) but rather something that is (re)produced through a complex multi-linear geometry of dispersed meanings which sustain it. It becomes an invitation to think about how “cultural quasi-neutrality” is dispersed through norms which sustain it (e.g., objectivity), how these norms are in turn sustained (e.g., cultural quasi-neutrality and politics are different arenas), and how such a norm flows through prismatic spaces which might come to produce it differently (e.g., science as always already being cultural).

The diffraction grating, while sharing similarities with the prism in terms of its disruption of epistemic pre-giveness, also includes a troubling of ontological pre-giveness within the scope of what is produced by critique. Informed by Barad’s quantum ontology and exploration of the undoing of classical optics, diffraction as critique is radical in its invitation to not only consider how the subjects and objects of critique are produced through their being in relation but that the very terms of a-count-ability are enacted through the critique. Neither are they one (i.e., monism) or two (i.e., dualism) prior the critique, but their entanglement of meaning and matter is qualified and enacted through the critique rather than before or after. In cross-cultural science education, this brings an important lens to consider the ways in which culture and nature, epistemology and ontology are co-substantiated without ever achieving one-ness or dualism. As science and science education practices are always already at the interface between nature and culture, the inclusion of nature within the flux makes it of greater consequence for and to critics who would dismay cultural critiques of science and science education as not being able to account for or be accountable to nature (e.g., Matthews, 1994). Furthermore, if the ways in which we know about nature are always knowing with nature and are always ways-of-knowing-in-being: what are the entangled epistemologies and ontologies enacted through such knowing? What network of human and other-than-human agents are co-substantiated within the production of such knowledge? If WMS considers itself as “culturally quasi-neutral” and a human endeavour, what can be learned from ways-of-knowing nature that actively consider the ways which they are produced with/in culture and with/in nature?
For critique to “be associated with more, not with less, with multiplication, not subtraction” (Latour, 2004a), there is an invitation to rethink critique as the “addition” of statements of lack as a mode of engagement as nothing new is added, never augmentend. Latour (2004a), by cheekily referring to this behaviour as sub-critical87, asks us to not take one idea and return less-than-one but rather bring it into conversation with more ideas that sustain it, and differentially shape it through and with a new network of ideas. This might allow for the multicultural science education debate to move beyond “what counts” as science (and in turn science education) towards understanding how “what counts” is produced and produceable in order to (re)open the structure of science education towards Indigenous science to-come. This might include considering the debate as operating through an adversary paradigm (see Chapter 2), the role of (an) ontology within the construction of “what counts” (see Chapters 4 and 5), or even the complex and complicated relationship between Indigenous and Western ways-of-knowing-in-being (see Chapter 6). If the goal is to augment through (re)placing our objects of critique with/in a complex and complicated web of knowings and beings rather than foreclose them as matters of fact or matters of fiction, then the use of multiple optical metaphors to achieve this purpose brings resources, not liabilities towards (re)opening science education towards Indigenous science to-come.

87 Thinking with Alan Turing, Latour (2004a) defines a sub-critical engagement as one in critique is done through substraction: “an idea presented to such a [sub-critical] mind will on average give rise to less than one idea in reply” (Turing, 1950 in Latour, 2004a, p. 248). Latour (2004a), like Turing, asks if critique can be super-critical, in that critique would take one idea and produces more than one rather than less than one.
Part 2: Tinkering with Ontology with/in the Multicultural Science Education Debate
Chapter 4: Tinkering with/in the Multicultural Science Education Debate: Towards Positing an Ontology

Continuing the deconstructive play of (re)signification of science education, labouring between what it is, is not, and could be(come), the purpose of this section is to continue working within and against the stratified and sedimented spaces of the multicultural science education debate. This extends upon the previous chapters’ work of (re)opening this debate by engaging in the play of (re)signification between the two predominant positions (i.e., cross-culturalist and universalist) as well as the modes through which the debate operates (e.g., dialectic, debate, critique as mirroring). Putting to work the alternative optical metaphors of the previous chapter (i.e., prism and diffraction grating), I consider how these common occurrences which present themselves with/in the multicultural science education debate are co-constituted by the uncommon and usually absent (see Derrida, 1976). This, in turn, allows for an exploration of the absent yet present co-constitutive elements of the multicultural science education debate that produces the ways in which Indigenous science is to-come, deferring and differing its arrival.

Thus, in this section, I latch onto the binary co-constitution of common and uncommon, and moments in which they vacillate, as a lever to (re)open spaces of science education to other meanings (e.g., Indigenous science to-come). In step, I draw from an ethic of deconstructive tinkering (Derrida, 1976) by using concepts, categories, and constructs that are uncommon to the context of multicultural science education to explore that which is common. In this chapter, this takes the form of (re)considering the role of ontology. As signaled in Chapter 2, Cobern and Loving (2008) remind that attention to ontology is uncommon within the multicultural science education debate. Where Cobern and Loving (2008) conclude that knowing nature through WMS is universal and “common sense,” I tinker with/in their criteria of ontological alignment to (re)situate this claim. However, before addressing this, I will quickly touch on what it means to engage in tinkering.

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88 Recall from Chapter 2 that the interplay of absence and presence signals the play of (re)signification. Absent presences are other(ed) signified meanings that might nonetheless retain the structure of the signifier that act as the constitutive otherness of that which is usually signified (see Spivak, 1993/2009). However, absent presences are not an unproblematic panacea: they are at once both unstated and un-assumed meanings (e.g., how claims of science education without scientism have not wholly done away with it) as well as those whose potentiality might allow for justice to-come (e.g., such as pedagogical plurality, allowing for Indigenous science to-come).

89 As Dr. Apffel-Marglin offers in the interview in Chapter 5, it is always important to remain open to knowledge outside of one’s particular disciplinary pathway. Drawing from that which is uncommon (i.e., other disciplines) can become productive tools to tinker with to (re)open the common (i.e., the occupied disciplinary space).
4.1 A Preamble on Tinkering: Derrida on the Porous Dichotomy Between Bricolage and Engineering

To frame the process of tinkering within this chapter, I turn to Derrida’s (1976) (mis)reading of Lévi-Strauss’ *La pensée sauvage* in which he both separates and blurs the distinctiveness between *engineering* and *bricolage*. In short, both engineering and bricolage are processes of and for generating knowledge claims. Engineering is the movement from the ends to the means, whereby the engineer makes appropriate selections from “the discourses of formal logic, and the pure sciences” (Spivak, 1976, p. xix), picking concepts, categories, and constructs already purposed for their process. In contrast, “the bricoleur makes do with things that were meant perhaps for other ends” (Spivak, 1976, p. xix). Through tinkering, bricolage reverses the ends/means hierarchy by privileging the means over the ends or the process over the product, even if this entails the very possibility of not achieving the specified goals. As Derrida (1976) argues, the ends (i.e., knowledge, truth) and the means of knowledge production (i.e., methodology) never come to coincide. The goal of (fully) achieving knowledge is not only empirically impossible, as Lévi-Strauss posited, but also theoretically so. Thus, for Derrida (1976), “the engineer should always be a sort of bricoleur” (p. 139) while coming to recognize the very limitation of bricolage:

> The only weakness of bricolage – but, seen as a weakness is it not irremediable? – is a total inability to justify itself in its own discourse. The already-there-ness of instruments and of concepts cannot be undone or re-invented. (pp. 138-139)

Just as the goals of engineering never come to be, Derrida cautions against treating the bricoleur’s tools as if they themselves always were. Instead, he invites consideration of the tools themselves as the productive enactments of bricolages past and to-come (see also Barad, 2010; St. Pierre, 2011a). There is always a need for “simultaneously troubling and using the concepts [and conceptual lines] we think we cannot think without…, keeping [them] as both limit and resource” (Lather, 2007, p. 167-168). Furthermore, because engineering/bricolage is always already a porous binary, this invites a critical consideration of bricolage vis-à-vis its ends, or what it produces: “all bricolages are not equally worthwhile. Bricolage criticizes itself” (Derrida, 1976, p. 139).

4.2 “Common sense,” Ontology and the Multicultural Science Education Debate

4.2.1 Having and being had by “common sense” during a science education project in Nunavut.

During the delivery of a curriculum in the Canadian arctic in which Indigenous (i.e., Inuit) and non-Indigenous youth explored differential cultural constructions of science through videography (see
Higgins, 2011, 2014a), I took up the call to examine and challenge the ways in which Eurocentrism “insidiously … maintain[s] the status quo” (Sammel, 2009, p. 651; see also McKinley, 2000, 2007) through involving youth in revealing, (re)structuring, and (re)directing the multiple ways in which dominance is maintained. I worked towards disrupting the concepts and categories that tend to create, and are utilized to uphold, inequality within science education, as well as the systems under which these inequalities become possible. Through this project, the youth involved learned and enhanced their movie-making skills and practices in order to explore, define, and document the diverse ways-of-knowing-Nature (i.e., science) that were enacted in their community of Iqaluit, Nunavut. This participant-directed videography work took various shapes: documentary-style interviews with community members within science and technology fields, as well as their own short movies which were a form of digital storytelling. Given that such an examination must also include the many bodies that occupy and uphold these systems within science education, I decided to engage simultaneously with the oft-cited “solution” of self-reflexivity through video diaries to analyze my/self as decolonizing pedagogue. Guiding this examination were questions into the ways in which I was participating in, (re)producing, and (re)produced by the culture of power.

This was useful in creating partial and side-long glances rather than penetrating gazes, producing complex and contradictory accounts of self. I was able to reveal/learn from some of the ways in which I was produced by and producing the culture of power within science education, and inadvertently pivoting rather than “transforming” my pedagogies and self as pedagogue. Nonetheless, through revisiting this data, it became apparent that I was reifying Eurocentrism through the very process of working against it. But then, as Battiste (2005) states, “Eurocentrism is not like a prejudice from which informed peoples can elevate themselves” (p. 122) as its pervasiveness renders it common sensical. As briefly mentioned in the previous chapter, within this last major research endeavour the decolonizing curriculum (e.g., border crossing) and “teacher-as-researcher” identities (e.g., culture broker) available worked both within and against a problematic center. As such, curriculum, pedagogy, and pedagogue were exceeded in pedagogical practice by the very coloniality the approach worked against, thus becoming de/colonizing (Higgins, 2014a; see also Carter, 2004, 2010). One could say that the common pervaded the uncommon; I held but was also being held by “common sense”.

As stated earlier, the very concepts we hold are always already exceeded by lived experience; lived experience provides deconstructive openings to think and act otherwise (Biesta, 2004; Bohm,
More than a niggling doubt about the porosity of that which earlier seemed solid, this double(d) pattern of holding and being held by “common sense” would become a location in which I would come to tinker. On being held by “common sense,” Battiste (2005) reminds that Eurocentrism is a “consciousness in which all of us have been marinated” (p. 124, emphasis mine). This similarity is pronounced by difference in intensity, degree, and duration such that it comes to produce us as de/colonizing subjects differently. If how we think is part of the problem, as Lather (2007) quizzically questions us, how do we, and can we, think about how we think without using the thing with which we think? It is a project framed by at once by necessity and im/possibility: an impossibility that when creatively strived towards reconfigures what critical possibilities are possible (see Barad, 2007, 2010; Spivak, 1993/2009).

In attempting to think about how I think, one of the most significant observations that I made through this analysis was that the continued appearance of Cartesianism as a common thread. At the time, I understood Cartesianism as “both the belief that various meanings and materialities are discrete quantities (e.g., mind/body) as well as the process through which they are separated from that which co-constitutes them” (Higgins, 2014a, p. 164, emphasis added). Like others (e.g., Pillow, 2003), I saw Cartesianism as a belief relegated to the realm of epistemology (i.e., knowledge about ontology, rather than or in addition to an enactment of ontology).

However, these qualities come to describe ways-of-being (i.e., ontology) instead of, or in addition to, ways-of-knowing (i.e., epistemology; see Chapter 2). Thus, what might it mean to take insights from the previous chapter (e.g., epistemology and ontology as co-constitutive and not pre-existing practice) and come to see Cartesianism not (only) as an epistemological facet of science education but (also) as one that is ontological? While questions of epistemology often take primacy due to uneven inter-cultural interfaces (i.e., dialectic rather than dialogue), it is productive to tinker with/in windy, indirect, and side-long approaches when the shortest path seems far too travelled. Responding to Lather’s (2007) question, it might be one approach to thinking without using the very thing with which you think (when the thing with which you think is part of the problem), recognizing that such is never (fully) achieved. Thus, what might it mean to (re)consider the multicultural science education debate with ontology in mind?
4.2.2 What’s ontology got to do with it? Revisiting the multicultural science education debate.

Science and justice, matter and meaning are not separate elements that intersect now and again. They are inextricably fused together, and no event, no matter how energetic, can tear them asunder (Barad, 2010, p. 242)

As Michiel van Eijck and Wolff-Michael Roth (2007) state, the ferocity with which the multicultural science education debate rattles taken-for-granted assumptions can be, to some, surprising. At the epicenter of this debate are questions of “what counts” as science within school-based curriculum. Largely at stake is the inclusion or exclusion of TEK and IWLN alongside WMS, as well as the norms through which they are included, excluded, and juxtaposed. This debate often presents science educators with diverse and difficult queries regarding what it means to respect students and the diverse ways-of-knowing-nature that they bring with them: can science (i.e., knowing nature) and justice (i.e., respecting diverse cultural knowledges) co-exist within the science education classroom?

Between science educators who champion the inclusion of TEK and IWLN as equally valid ways of knowing nature (i.e., cross-culturalists; for example, Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001) and those who do not consider these ways-of-knowing-nature as equally valid to the “universal” standard of WMS (i.e., universalists; for example, Cobern & Loving, 2001; Siegel, 2001), this aforementioned question (and false dichotomy; see Chapters 2 and 3) continues to produce friction that is not always generative. As there continues to be an ongoing and ever-present need to respond to the conflicting and potentially incommensurable demands between epistemological validity and ethical responsiveness in science education, there have been multiple attempts to resolve the debate (see Chapter 2), by working towards producing modest intermediary positions that attempt to develop and enhance potential points of agreement between positions (Alsop & Fawcett, 2010; Cobern & Loving, 2008; van Eijck & Roth, 2007). An example of such a point of agreement is that while universalists and cross-culturalists generally do not agree whether or not science education is or is not a frequent site of scientism, indoctrination, or imposition, they both agree that it should not be. In the last few years, attempts to labour from shared assumptions towards intermediary positions have included: a) positing an ethics of incommensurability or co-existence

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90 Here equally valid does not signify that TEK and IWLN achieve equivalence or sameness with WMS, but rather that they offer something that is of similar importance (e.g., the former presents frames for ethical and sustainable practices of living with nature while the latter offers quantifiability, reproduceability, and predictability through laboratory-based experimentation; see Aikenhead & Michell, 2011; Aikenhead & Ogawa, 2007).
(e.g. El-Hani & de Ferreira Bandera, 2008; El-Hani & Mortimer, 2007; van Eijck and Roth, 2007),
b) considering diverse and competing scientific knowledges as (re-)contextualized processes rather
than inert knowledges (van Eijck and Roth, 2007), and c) pedagogically enacting an ethics framed
by the vulnerability of not knowing (Alsop & Fawcett, 2010).

However, in this section, I take up the possible pathway put forth by Cobern and Loving
(2008). In short, Cobern and Loving (2008) posit that most proposed and partial responses to the
multicultural science education debate largely center upon questions of epistemology. Given the
predominantly socio-cultural characteristics of the debate, this is not without cause. However,
Cobern and Loving come at the debate sideways by tinkering with that which remains uncommon to
questions of and in multicultural science education: ontology. In response to epistemic primacy, to
explore how scientific knowledges might have “characteristics of verisimilitude, vis-à-vis the real
world” (p. 440), Cobern and Loving suggest that the “real world” too must be seriously considered
in the equation. Thus, instead, or in addition to strictly epistemological undertakings, Cobern and
Loving (2008) propose that this debate be addressed through a (re)consideration of how the subject
of scientific knowledge aligns with its object, or how epistemology (i.e., Culture) aligns with
ontology (i.e., Nature). Through an exploration of ontological situatedness, and within the context of
the multicultural science debate, the conclusion that Cobern and Loving (2008) reach is that
“epistemological realism [i.e., epistemology of WMS] is literally the common ground—the common
sense—we all share” (p. 443).

Drawing from insights from the previous chapters, the purpose of this chapter is not to de
ny the claim made by Cobern and Loving (2008) that “Epistemological Realism Really is Common
Sense” (p. 425) by presenting it through a metaphorical mirror as either fact or fairy. Rather, it is to
tinker with this uncommon approach to justify common sense; there are productive insights to be
gained through using and troubling the notion that they put forth. In particular, drawing from the
Chapter 3’s optical metaphors, what would it mean to treat the statement as more than true or a false
reflection of reality? What insights could be gained by (re)situating a “mirroring” statement (i.e.,
“characteristics of verisimilitude, vis-à-vis the real world” [Cobern & Loving, 2008, p. 440]) by
thinking pristically and diffractively with and about it? In particular, what would it mean to focus
on how epistemological realism as “common sense” inflects and is inflected, how it is produced and
what it produces? If epistemological realism is “common sense,” to whom is it common (e.g., is the
“we” in the “common sense – we all share”[Cobern & Loving, 2008, p. 440] in fact all of us or but
For epistemic realism to be “common sense,” what epistemological and ontological criteria need to be in place? How did this “common sense” come to be (made) common (i.e., through dialectic rather than dialogue)⁹¹? What does this “common sense” produce? Is “common sense” something we have, are had by, or a combination of both? Lastly, as “science and justice, matter and meaning are not separate elements that intersect now and again” (Barad, 2010, p. 242)⁹², what does it mean to consider ethics and justice as co-constitutive elements of ontologically situated scientific epistemologies?

4.2.3 Epistemic realism and/as “common sense?” Ontological situatedness and/in the multicultural science education debate.

Cobern and Loving (2008) state in “Epistemic Realism is Common Sense” (p. 425) that a collusion of forces have made it such that there seems to be less discussion within science education with respect to how epistemological frameworks align with the ontological reality that they attempt to represent. These factors include, but are not limited to: the move towards constructionism and socio-constructionism in science education as well as education writ large, a growing doubt towards WMS following a series of public opinion altering watershed moments (e.g., Agent Orange, napalm, Hiroshima), as well as a Kuhn’s introduction of paradigms and the sudden appearance of a plenary of competing paradigms due to an increasingly multicultural social reality. The argument made is that the move to make space for what Cobern and Loving (2008) refer to “ideas that heretofore would have been called ethnoscience and folklore, pseudoscience, and even quackery” (p. 435) has meant that the focus of multicultural science education has shifted towards epistemological pluralism as a means of attempting to account for these diversely positioned ways-of-knowing-nature. While Cobern and Loving (2008) might bemoan the impact that these diverse educational and social shifts have had, and how they have reshaped multicultural science education as it is today, others have

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⁹¹ Latour (2004b) reminds that common sense and good sense are often opposed rather than one and the same. However, he goes on to suggest that if the “good-ness” of sense is pre-supposed, the possibility of meaning being made through common understanding (i.e., dialogue) rather than made common through dialectic is (fore)closed.

Also, the question of how this particular “common sense” is produced and what it produces in turn is taken up in far greater detail in the latter half of this section (i.e., Chapter 5).

⁹² This is to be differentiated from the taken-for-granted relationship that Barad (2000) alerts us to: one in which scientific literacy is perceived as always already ethical. As she states, it is often assumed that:

[There is an] equivalence relation between the possession of scientific knowledge and being socially responsible [that] is often implicit in discussions about scientific literacy: this is the notion that familiarity with the facts and the methods of science is all that is required for socially responsible decision making concerning science- and technology-related issues. (p. 227)

This ontological pre-determination of ethicality masks the ways in which the (im)possibility of ethics is never fully achieved or achievable as well as how science and science education must always remain ethically on the move and vigilant to respond to an ever evolving set of ethical problems and possibilities (see also Roth, 2003).
seen these as deeply productive locations and levers to pry open the spaces of science and science education (e.g., Haraway, 1997; Latour, 1993; Snively & Corsiglia, 2001). While I stand with the latter and disagree with the premise that Cobern and Loving (2008) put forth, there is nonetheless some merit in exploring their argument: not necessarily to prove it right or wrong, but rather to explore how it is produced, produceable, and what it produces with/in discursive spaces of science education.

Cobern and Loving (2001, 2008) argue that questions of cross-cultural integration, interfacing, and understanding often neglect asking questions about how these meanings necessarily interface with the nature of Nature. They state, given the plurality of epistemic frameworks, that there needs to be pragmatic criteria through which systems of knowing nature (i.e., science) are deemed valid and valuable:

Interpretations of experience are all one can know... One accepts the validity of interpretations in so far as they are pragmatically viable... Historically we [Western modern scientists and science educators] have believed in the ontological reality of the world and trust our epistemological efforts to describe that reality and yet always do our epistemologies fail to demonstrate that what we think we know really is what is. (Cobern and Loving, 2008, p. 433, emphasis in original)

For Cobern and Loving (2001, 2008), amongst many other science educators, that criterion is experience: a statement that both universalists (e.g., Matthews, 1994; Siegel, 1997, 2001) and cross-culturalists (e.g., Aikenhead & Michell, 2011; Barnhardt & Kawagley, 2008; Cajete, 1999; Snively & Corsiglia, 2001) would agree with. However, there is a significant point of deviation in how experience is both understood and enacted (e.g., experience as Truth, experience as situated and partial, having and being had by experience93, experience as relationality). Whether intentional or unintentional, Cobern and Loving (2008) utilize this conceptual plurality and undecidability as location to present a false dichotomy:

It is true that we cannot know with certainty that perceptual and experiential experiences are significantly grounded in ontological reality. However, it is equally true that we cannot know for certain that perceptual and experiential experiences are not significantly grounded in ontological reality. (Cobern and Loving, 2008, p. 441)

The false dichotomy presented here is either one in which epistemology is ontologically situated within “ontological reality” by utilizing an “ontological realism that very few educators would reject” (Cobern and Loving, 2008, p. 437, emphasis in original) or the meaning made is anti-

93 Being had by experience might signal the ways in which we might not 'have' experiences but rather, due to not 'having' a static body of meaning or matter (i.e., the meaning and matter which makes us is never fully ours; distributed agency; see Barad, 2007; Butler, 2005), experiences, when we are had by them, are the marks left on our body (of meaning and matter) from the intensities and flows within the multiple assemblages we find ourselves in and the affective movement of meaning, matter, spirit with/in/around the re(configured body we are part of (see Apfell-Marglin, 2011).
ontological and not grounded in reality in as meaningful a way or at all. This false dichotomy relies upon the absent yet present common sense assumption that “ontological reality” precedes meaning making, is singular, unified, and is the ontological reality defined and enacted by WMS (see Chapter 3). Thus, by (re)presenting and casting approaches that don’t fall into the classical cannon of epistemic realism into (absolute) relativism, a “a pejorative as far as [they] are concerned” (p. 437), the alternative they present is but a strawman or a trick of smoke and mirrors as discussed within the previous chapter.

Further, it can be argued that the approach presented by Cobern and Loving (2008) does not bring us closer to resolving the multicultural science education debate: it simply displaces the terms of the debate elsewhere (i.e., ontology rather than epistemology). Such a displacement (re)produces a similar but different argument whose goal is to dialectically negate, subsume, or suture over the opposing view rather than create something else, something in-between through dialogue. In other words, the ontological situatedness that Cobern and Loving (2008) call for is but another means of reaffirming science, or WMS to be specific, as universal.

However, considering the notion of ontological situatedness can still bear fruit in the context of multicultural science education: what if epistemic realism best aligned with an ontology rather than simply “ontology”?

### 4.2.4 From ontological alignment to positing an ontology in science education.

How reality is understood matters. There are risks entailed in putting forward an ontology: making metaphysical assumptions explicit exposes the exclusions on which any given conception of reality is based. But the political potential of deconstructive analysis lies not in simply recognizing the inevitability of exclusions but in insisting on accountability for the particular exclusions that are enacted and in taking the responsibility to perpetually contest and rework the boundaries. (Barad, 2007, p. 205, emphasis in original)

Cobern and Loving (2008) highlight that “we face a metaphysical choice” (p. 441) in science education. This choice is situated within the realm of metaphysics as it asks us to consider the relationship between epistemology (i.e., Culture) and ontology (i.e., Nature). Within science and science education, this relationship between epistemology and ontology has been understood through competing claims of weak and strong forms of relativism and realism. In other words, the way in which this has primarily been taken up by science and science education scholars is through the critical and metaphysical questioning of the extent to which epistemology aligns with ontology.

Within the context of science, as Latour (1993) posits, most scientists reject absolute relativism (i.e., everything is cultural) as it requires the bracketing out of Nature. Similarly, scientists
often also reject absolute realism (i.e., everything is natural) as it wholly brackets out Culture. Thus, as scientists generally agree that scientific knowledge is shaped by both natural and cultural factors, scientists more frequently adopt a weaker form of relativism or realism. While Nature and Culture are kept separate for both realists and relativists, there is always a relationship between Culture and Nature such that diverse cultures have different modes of accessing Nature. What is contested between the two approaches is whether knowledge about nature can be explained primarily but not exclusively through natural factors (i.e., weak realism) or through cultural factors (i.e., weak relativism). Within science education, similar discussions of realism and relativism take place (see Chapter 2) and are often included in curricula through exploration of the nature of science (NOS). In short, NOS addresses how the culture of science epistemologically understands and comes-to-know the nature of nature, or ontology (e.g., Holbrook & Rannikmae, 2007; Plakitski, 2010; Rudolph, 2000).

However, “as soon as Nature comes into play without being attached to a culture, a third model is always secretly used” (Latour, 1993, p. 104). Latour (1993) refers to this as “particular universalism”: a framework in which Nature is stable and outside of Culture and diverse cultural positionings mediate access to knowledge about Nature. The caveat, and mean through which WMS maintains primacy, is that “one society - and it is always the Western one - defines the general framework of Nature with respect to which the others are situated” (p. 105). In other words, defining how Nature operates94 is established as and establishes epistemic privilege for WMS.

Furthermore, for reasons that include but go beyond the troubling of this epistemic privilege, many critical science scholars (e.g., Barad, 2007; Kirby, 2011; Latour, 1993) have begun to examine and cast doubt upon the framework(s) through which questions of relativism and realism come to be argued. Under critical examination is the oft taken-for-granted assumption that many realist and relativist frameworks rely upon: Nature as a stable backdrop upon which Culture plays out. Critical science scholars, such as Haraway (1997) and Latour (1993), have long challenged the oft-accepted notion that “epistemology models ontology” (Polkinghorne, 1991, p. 304 in Cobern & Loving, 2008, p. 442). Returning to the metaphors explored in the previous chapter, it could be stated that the notion of epistemology mirroring ontology is suspended. As Barad (2007) reminds, critical science

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94 Notably, particular universalism dictates how Nature operates without Nature’s consent (see Barad, 2007, 2012b). As Latour (1993) and Cajete (1994, 2000) state, this double(d) othering of Nature and of other-than-Western cultures are not separate nor separable enactments but rather differential enactments of the same, intertwined through a practice of cultural “transcendence” in which WMS sees itself as neither having a culture nor being part of Nature.
scholarship has been laboring to displace these arguments by reading them through cultural lenses to explore what it mean to inflect ontology prismatically through epistemology. By showing how the culture of science has an active role in producing scientific knowledge, this opened up rich lines of questioning regarding epistemology as always situated and partial, as well as the development of an ethics that might go alongside (e.g., Harding, 1986, 1993/2004; Latour, 1993). However, as discussed in Chapter 3, what if the nature of Nature, or ontology, were not stable and passive (i.e., the condition required for both the mirror and the prism) but rather dynamic, agentic, self-differentiated, and in an ongoing state of becoming (see Barad, 2007, 2010)\(^95\)?

Within what is being referred to as the “ontological turn,” Barad (2007) draws from Neil Bohr’s philosophy-physics to posit that ontology is not something that exists \textit{a priori}. This is to say that scientific phenomena under observation do not pre-exist their observation, rather, they are enacted with and through observation. Ontology is not separate or separable from epistemology, but rather is always entangled, super-positioned, and diffracted. Matter comes to matter in both senses of word: it is at once important and worthy of consideration; as well as something that comes into being rather than remaining inert, static, and unagentic (Apffel-Marglin, 2011; Barad, 2000, 2007, 2010; Kirby, 2011).

While the realm of matter and materiality (i.e., Nature) has always been the primary focus and domain of science education, a (re)consideration of how matter comes to materialize has important consequences for science education in terms of epistemology, ontology, as well as ethics. Of particular importance, and a focus in this chapter, is that problem and possibility that ontology is not, and has never been, a singular affair (Barad, 2007). Rather, it is always already plural and becoming differential through the working and reworking of metaphysical cuts (e.g., the norms of bodily production – subjects and objects).

To situate science and science education ontologically requires one to posit \textit{an} ontology, as opposed to simply situating within “ontology” (read: singular). \textit{An} ontology is an ever-partial (i.e., having exclusions) but never relativistic accounting for an always shifting Nature. Barad (2007) reminds us that part of the positing of \textit{an} ontology goes beyond naming \textit{which} ontology is at work: the “accountability for the particular exclusions that are enacted” through our metaphysical choices.

\(^{95}\) This is of particular significance as Nature as agentic, differentiated, and fluid is important to how an Indigenous “sense of place” is understood and enacted (see Cajete, 1994, 2000; see also Chapter 2).
includes “taking the responsibility to perpetually contest and rework the boundaries” (Barad, 2007, p. 205).

To consider an ontology thus requires, as Barad (2010) states, to consider how “science and justice” as well “matter and meaning are not separate elements that intersect now and again” (p. 242). If competing ways-of-knowing-nature are separated from their co-constitutive ontology and required to align with an ontology, specifically the ontology of WMS, then what does it mean to account for and being ethically accountable to this new entanglement? What is produced and what is produceable?

4.2.5 Conclusion: Positing an ontology in multicultural science education.
The positing of an ontology and striving towards accountability for ontological enactments is of importance for scholars working within the context of multicultural science education. To take up the call to posit of an ontology would necessarily require moving from questions of epistemology to questions of epistemology and ontology, or even onto-epistemology (i.e., the co-constitutive entanglement of knowing and being; see Barad, 2007, 201096) to ask the question of how epistemology and ontology come to co-constitute one another.

Thus, returning to the “metaphysical choice” that Cobern and Loving (2008) present, one that asks which scientific epistemology best aligns and correlates with “ontology” (read: singular), it is fair to state that no choice is offered at all. They put forth, “there is simply no other rational way to account for human ability to increase instrumental epistemological power other than that knowledge has the characteristics of verisimilitude, vis-à-vis the real world.” (p. 440). Here, because an enactment of the “real world” is already chosen by and/or for them, the “rational way” that Cobern and Loving’s (2008) “common sense” metaphysical choice suggests is, again, WMS. Rather than present a modest intermediary position, I suggest that Cobern and Loving (2008) simply displace the terms of the multicultural science education debate by (re)presenting them anew, albeit elsewhere (see van Eicjk & Roth, 2007). However, what occurs to other-than-WMS ways-of-knowing-nature when they are asked to “mirror” a Cartesian ontology?

While there have been invitations to position diverse ways-of-knowing-nature ontologically, their alignment with the ontology of WMS produces a problematic configuration. It explicitly enunciates and upholds the often implicit message that approaches other than WMS are lesser means

96 Onto-epistemology can neither be adequately referred to as both ontology and epistemology, nor the two as one, but rather a state of superposition and co-constitution (see Barad, 2007, 2010).
of knowing nature by continuing to not only center this ontology but also failing to acknowledge that it is but one possible ontological possibility amongst many. Take for example Siegel’s (1997) positioning of diverse ways-of-knowing nature other than those of WMS:

Science education must … treat members of minority, dominated cultures with respect. And it must treat the scientific ideas of these cultures with respect. But so treating these cultures and their scientific beliefs and ideas does not require those ideas be treated as correct or as correct as the scientific ideas of the dominant, hegemonic culture. (p. 101).

Such often unacknowledged and taken-for-granted ontological positioning and posturing continues to have adverse effects on if, and how, TEK and IWLN are included within multicultural science education (see Aikenhead & Michell, 2011; Sammel, 2009). In short, when TEK and IWLN are articulated within and/or in relation to WMS’s ontology, they are not only fragmented but also potentially produced as lesser means of knowing Nature through Cartesianism.

The ontology through which WMS comes to be, Cartesianism, is the classical Western modern ontological process through which meaning and matter are individuated through separation from that which co-constitutes them (e.g., mind/body dualism). TEK and IWLN, due to their particular relational entanglements of matter and meaning, fail to (fully) fit the constructs, categories, and concepts enacted by such an ontology; making Cartesian cuts renders many aspects of TEK and IWLN absent presences (e.g., Nature as agentic; see Cajete, 2006). While many science educators have argued that TEK and IWLN stand up to the terms of WMS (e.g., validity, reliability, empirical observation, repeatability), they never stand up as well as WMS on WMS’ terms (Aikenhead & Michell, 2011; Cajete, 1994, 2000). Furthermore, such a deficit-based framing (i.e., how it fails to fit WMS’s epistemological and ontological enactments) obscures the importance distinctions, as well as rich contributions that TEK and IWLN have to offer from that which exceeds WMS (e.g., ethics of regeneration, spirituality; see Apffel-Marglin, 2011; Cajete, 1994, 2000).

TEK and IWLN’s alignment with Cartesianism will always result in theories that are viewed as not “as correct as the scientific ideas of the dominant, hegemonic culture” (Siegel, 1997, p. 101, emphasis in original). They fail to cleanly fit the separate and mutually exclusive ontological and epistemological categories established by WMS because TEK and IWLN do not make such clean and clear cuts between epistemology and ontology and their constitutive domains. This is not to state that it is inherently wrong in an absolute sense to center Cartesianism, and that there are not

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97 It is important to note however that Cartesianism and Eurocentrism co-constitute one another and that particular attention needs to be paid to how these produce science education and educator, as well what such a science curriculum and pedagogy might come to produce (see Higgins, 2014a; see also Apffel-Marglin, 2011; Battiste, 2005; Cajete, 1994).
moments in which it is an appropriate ontology to posit (e.g., when considering WMS). However, to posit an ontology is to be held accountable to the patterns of difference, the lines of inclusion/exclusion that are produced through the “metaphysical choice[s]” that we make. Thus, to posit an ontology invites a differential consideration and an ongoing accounting for and ethical accountability to the ontological norms through which TEK and IWLN have been included or excluded from science education. To posit an ontology also invites a curricular investigation of how diverse knowledges are ontologically situated and produced, without needing to resort to relativism (see McKinley, 2007).

Despite the importance of considering an(other) ontology that is to come in the later chapters of the dissertation (e.g., Barad, 2007; Cajete, 1994; Lenz-Taguchi, 2010; see Chapters 6 and 7), it is important to consider Cartesianism as an ontology. As Spivak (1976) reminds us, the language we possess also possesses us; to (too) simply abandon a particular does not mean that it has abandoned us. If the thoughts we have and by which we are had are part of the problem, it is not so simple to think about how we think without using the thing with which we think. Lather (2007) suggests a double(d) reversal of the ethnographic gaze to consider not only the ways in which thought is prismatically inflected, but also the entangled apparatus through which thought it is produced and produceable. Such a double(d) reversal entails both the literal reversal of studying those who do the studying (i.e., in order to reverse the direction of the ethnographic gaze), as well as the study of the way in which those who do the studying study (i.e., in order to reverse the way in which the ethnographic gaze is produced). In the second half of this section (i.e., Chapter 5), I engage with and through an interview with Dr. Apffel-Marglin who engaged in the difficult task of a double(d) reversal around how Cartesianism is produced and what it produces.

98 Part of the reason for this, if we take Barad’s (2007) notion of onto-epistemology seriously, is that the epistemology and ontology of WMS are always already simultaneously enacted (see also Latour, 1993, 2004b). Furthermore, it has been argued that the two were also historically co-developed (see Apffel-Marglin, 2011).
Chapter 5: Considering Cartesianism as an Ontology Within Multicultural Science Education with Dr. Frédérique Apffel-Marglin

Within this chapter, I continue the tasks undertaken in the previous chapter: tinkering with/in the multicultural science education debate using ontology. Recall that I used and troubled Cobern and Loving’s (2008) suggestion that the primary and almost exclusive focus on epistemologies within the multicultural science debate has detracted from considerations of how epistemology aligns with ontology. It was demonstrated that Cobern and Loving use this (re)signified natural-cultural interplay to make a stronger case for universalism (i.e., “Epistemic Realism Really is Common Sense” [p. 425]). However, I argued there is nonetheless room for the possibility for something else to emerge from this insight by differentially engaging with it, particularly, if we also take seriously the notion that ontology is not a singular affair. From this, a move to recognize plurality can be achieved not by refuting Cobern and Loving’s claim but rather by (re)situating it within a context. Specifically, an epistemology of epistemic realism (i.e., the epistemology of WMS) really does align best with an ontology of Cartesianism (i.e., the ontology of WMS). To recognize that Cartesianism is but an ontology creates space in which WMS achieves “distinction not privilege” (Cobern and Loving, 2008, p. 444), not requiring universalists’ claims of onto-epistemic alignment to be refuted.

Notably, this potential for science without scientism as well as Indigenous science to-come requires that science educators accept responsibility towards positing an ontology, accounting for said ontology, and finally being accountable towards how it is produced and what it produces. Given science education’s norms and history of inclusion/exclusion around TEK and IWLN, positing an ontology invites a (re)consideration of science education’s complimentary and supplementary spaces of knowing nature. Specifically, this calls for a renewed engagement with TEK and IWLN. As each has their own distinct onto-epistemological alignments or entanglements, positing an ontology calls for an ethical response-ability to account for relational ways-of-knowing-in-being’s ontological co-constitution without necessitating alignment with Cartesianism. Engagement in such ontological pluralism need not rely on ontological or epistemological relativism as there continue to be meaningful patterns of differentiation and similarity available for productive engagement (see McKinley, 2007).

Before getting on to the work of positing an(other) ontology that might be more commensurate with Indigenous science (to-come; see Chapters 6 and 7), I investigate what it might mean to account for and be accountable to an ontology of Cartesianism? To engage with this
question, it is productive to ask: *How, where, and when did Cartesianism as “common sense” become common? How was Cartesianism produced? and What does it make produceable in turn?* Thus, I continue tinkering (i.e., using that which might be intended for other uses) with ontological absent presences. I trace how the *there-thens* of Cartesian “origins” are entangled with *here-nows* (see Barad, 2010), playing an active role in (re)shaping possible possibilities within multicultural science education. To achieve this, I draw from and diffractively read a series of expert interviews with Dr. Frédérique Apffel-Marglin’s that unpack the historical, geographical, political, economic, and religious forces of the “birth of modernity” and reveal the ways in which this “common sense” went from being uncommon to common and continues to persist.

Before this diffractive reading, I present a positional vignette to both introduce the work to come and my (co-constitutive) relation to the work herein. A methodological section on (re)thinking expert interview diffractively follows.

### 5.1 Pathways of Chance: Encountering Dr. Frédérique Apffel-Marglin.

What if we leave room in our lives for chance and the unexpected?... Instead of seeing’ one’s life planned out into the future like a vast highway, life only makes sense to us when we look back to the past and see the path we have taken with all its diversion, U-turns and side roads. There may have been no fixed plan for the future but looking back at the map of one’s life journey it almost seems as if there had indeed been a goal all along, but a goal that had been concealed at every step of the way. (Peat, 2007, pp. 15-16)

As Peat (2007) elaborates in his “little” autobiography, our lived experiences cannot be mapped so easily: we are always walking along “pathways of chance.” A probabilistic approach might see us treading common paths more often than those uncommon. However, when we encounter the uncommon “do we compensate as best we can in an attempt to remain on our predetermined track?” (p. 15). Peat suggests that if “we leave room in our lives for chance and the unexpected” (p. 15), we may come to encounter new relationships as well as old relations anew. Such encounters can gently inflect our life’s journey or throw into new directions altogether, into unanticipated spaces and places that we may only be able to make sense of in retrospect, if at all. Just as Peat’s life was thrown into another orbit altogether through meeting his mentor-to-be David Bohm, as well as the Blackfoot peoples (and Blackfoot scholars like Leroy Little Bear), my encountering Dr. Frédérique Appfel-Marglin was a meeting of the latter pivotal type.

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99 The scare quotes here are intentional as origins are forever deferred and differing (see Derrida, 1976). Dr. Apffel-Marglin makes explicitly clear that the “birth of modernity” is not an “origin” in the conventional sense but rather a partial and contingent origin: *a* historical moment in which modernist thinking is operationalized (see Apffel-Marglin, 2011).
I first textually encountered the work of Dr. Apffel-Marglin in the fall of 2010 during an
assigned reading in a graduate class on Indigenous education within her edited collection *The Spirit
of Regeneration*. This opened my eyes to the incredibly useful potential of thinking about questions
of (neo-)coloniality and Indigeneity anew by considering the global South and those working with
the global South when thinking about and with questions of de/colonizing education. I would not
meet her in person until the spring of 2012, during an invited talk at the University of British
Columbia. During this talk, she was showcasing her recently released book *Subversive Spiritualities:
How Rituals Enact the World* that, as she states, was “the fruit of a lifetime of anthropological
practice” (Apffel-Marglin, 2011, p. 7). Centering the pedagogical potentiality of ritual enactments,
the purpose of the talk and of her book, as she states:

is an effort to articulate the nature of the kinds of beings I spoke with and gave gifts to in rituals. Here I
attempt to articulate for people like myself what my new manner of practicing rituals has revealed to
me about our (i.e., the modernist) way of representing reality. (Apffel-Marglin, 2011, p. 8)

Her life’s work has not only focused on understanding ritual enactments, but also what ritual
enactments reveal about Western modern ways-of-knowing-in-being (e.g., how Western modernity
produces matter and meaning and what these in turn produce). Thus during this talk, she spoke of
“twin journeys” which are highly commensurate with Battiste’s (2013a, 2013b) conception of
decolonizing as deconstruction and reconstruction: a double(d) reversal which she referred to as
“reverse anthropology”:

By “reverse anthropology,” I do not mean [strictly] engaging in ethnographic research on some aspect
of American or European culture or society. Rather, I mean an understanding of the processes that
have brought about our way of seeing reality – all of it, not just a single, particular aspect. By “our way
of seeing reality,” I mean what we take for granted; by “we” I mean people like me, educated in the
modern educational system that by now is hegemonic and thus no longer tied to any specific region or
ethnic group; by “reality” I mean things as fundamental as time, space, and nature as opposed to
culture, the human person, and so forth. (Apffel-Marglin, 2011, p. 11)

In other words, this double(d) reversal entails both the literal reversal of studying those who do the
studying (i.e., in order to reverse the direction of the ethnographic gaze), as well as the study of the
way in which those who do the studying study (i.e., in order to reverse the way in which the
ethnographic gaze is produced). It is a differential means of working towards thinking without the
thing with which we cannot think without (Lather, 2007). Furthermore, this double(d) reversal is not
without significance: to make rituals and the insights they provide “understandable and credible
requires nothing less than a deconstruction of the modernist onto-epistemology” (Apffel-Marglin,
2011, p. 14) which render ritual Other. These include addressing a constellation of inter-connected
concepts enacted through practice, including the separation of Church and State in most Western modern contexts as well as the multiplicitous ways in which most non-Western, non-modern ritualized spiritual enactments are often exoticized and branded as “irrational animism” (see also Cajete, 1994, 2000; Marker, 2006). In order to make space for spirituality, she delivered a rich and robust critique of modernity, its teleology of progress, and its narrative of development by coming at modernity via multiple angles: social, political, religious, military, historical, and economic. From here, she labored within, against, and beyond modernity by employing a reconstructive frame that interfaced quantum ontologies (to work within and against modernity) and Indigenous ways-of-knowing-in-being (to work within and beyond modernity). This framework was primarily offered as a way to think and enact the world otherwise through ritualized action.

Turning towards Dr. Apffel-Marglin’s work around ritualized actions that “enact the world in concert with its humans, non-humans, and other-than-humans” (Apffel-Marglin, 2011, p. 15) might seem uncommon for a science educator or within science education. Apffel-Marglin (2011), like Peat (2002, 2007), reminds that it is always important to remain open to knowledge outside of one’s particular disciplinary pathway. She highlights the importance of being inter- or trans-disciplinary as “it has the distinct advantage of being less prey to the tacit knowledge hidden in entrenched fields and subfields of European studies and in particular in the boundaries creating such fields and subfields” (p. 14). However, there were far more spaces of potential connection and commonality than I had or could envision at the time of first encountering her work. For one, ritualized action has many connections to how IWLN are articulated:

Ritual is the medium for communicating, reciprocating, creating, and working with the other-than-humans, who daily remind the humans that the world is not for humans’ exclusive use. It is the other-than-humans who make clear to the humans that human desires are not the only ones. In other words, they make clear that humans are not the masters of this world, and in turn that this world is not agency-less and voiceless, a sum of natural resources to be indefinitely mined to feed the supposedly infinite desires of human beings. (Apffel-Marglin, 2011, p. 6)

These formalized processes and protocols of and for communal (inter-)being have the aim of (re)generating and the sustaining of “the iterations of the cycles of life” (p. 41), reminding that we are not passive observers outside of the world but rather active participants within. Similarly, with respect to Indigenous science, Cajete (1994) states that:

Scientists study the tracks of subatomic particles that exist only a millionth of a second. They find the human observer influences the energy relationships and even the nature of existence of these subatomic particles. Humans do participate with everything else even at this level of natural reality. Indigenous people understood this relationship of human activity as concentric rings that extend into the spirit realm. (Cajete, 1994, p. 55)
As Cajete articulates further, “it is no accident that learning and teaching unfolded in the context of spirituality in practically every aspect of traditional American Indian [Indigenous] education” (Cajete, 1994, p. 41). If I found many productive points of resonance with Frédérique Appfel-Marglin’s work, and could learn much from her, is because the degrees of separation between the spaces we respectively attempt to foster were far smaller than one trained in the academy might imagine at first. Furthermore, and of equal importance, the locations that Dr. Appfel-Marglin laboured within and against in order to make space for Indigenous ritualized enactments were even closer: as this involved critically inhabiting and tinkering within the spaces of and related to WMS. There was much I could and can still learn from her life’s labour in this arena.

Encountering Dr. Appfel-Marglin was an unexpected turn along my own personal pathways of chance; it was an encounter that subverted the very ways in which I could be in the world, I could not (not) take up what she had offered. This (re)ignited my own interest in metaphysics, the cross-cultural space between Indigenous ways-of-knowing-in-being and quantum ontologies, as well as the importance in coming-to-know the very space that I am operating within and against to allow for a possible possibility of there being a beyond. This encounter also sparked my imagination with respect to the educational possibilities lying therein, which come to inform the later chapters of the dissertation. It so happened that Drs. Peter Cole and Pat O’Riley were hosting a University of British Columbia summer institute in Peru the summer after which Dr. Appfel-Marglin visited the University of British Columbia to give her talk. This would be located at the Sachamama center that she ran, located in the San Martin Department of Peru and on the ancestral territories of the Kichwa-Lamista peoples. Attending this summer institute meant that there would be a possibility to engage with Dr. Appfel-Marglin in person but also a possibility of holding an expert interview. Sensing an opportunity that should not be missed, I had a desire to document to allow for these rich teachings to disperse: I would interview Frédérique as part of a tinkering process in which I did and would not know the end result. So I sent out an invitation to do so (see Appendix A). The same day, she replied: “I would be delighted to participate in a dialogue or interview with you and very much look forward to it” (Dr. Frédérique Appfel-Marlin, personal communication, February 14th 2013).

5.2 Tinkering with/in Expert Interview: De/signing Research Methodology.

Wanting to recognize Dr. Frédérique Appfel-Marlin’s “lifetime of anthropological practice” (Appfel-Marglin, 2011, p. 7), the methodological structure with which I sought to tinker was that of expert interview. As Bogner, Littig, and Menz (2009) state, “there is no such thing as the expert
interview” (p. 6, emphasis in original). Rather, they are differential inflections on more general interview practices that predominantly hinge upon conceptual considerations of “what counts” as “expert,” “expert knowledge,” as well as what the aims and purposes of an expert interviews might be. Thus, expert interview presents itself as a methodological structure that is constituted by the ways in which the key concepts are understood and enacted. As Bogner, Littig, and Menz (2009) frame, a topology of expert interviews would primarily include, but would not be limited to: a) expert interview as exploratory, to provide orientation into further inquiry; b) expert interview as systematic retrieval, to acquire “expert knowledge” from an “expert”, and; c) expert interview as theory-generating interactive exchange.

Working towards the third type entails working within and against the second type: where notions of fact and fairy come to haunt accounts as adequately or inadequately mirroring reality (see Chapter, 3), putting into question the status of and possibility of ever achieving “expert” and “expert knowledge.”

Regardless of what might be myth and what is reality, the anticipated promise of rapid and unproblematic access to objective data makes expert interviews an extremely appealing option for empirical social researchers. But is the expert interview method really quite so simple and uncomplicated? If so, does this then render methodological considerations superfluous? Or are expert interviews in some ways just too tempting? Do they not – in their naïve belief in the totality of expert knowledge – harbour the danger of advocating a pre-reflexive definition of what constitutes an expert? (Bogner et al., p. 2)

In turn, the practice of methodological tinkering continues to bear importance and relevance\(^{100}\); methodology is always already a space with/in which to tinker with purpose but without guarantee.

Expert interview as methodology would require tinkering with so that it was not presented as the truth, but rather a truth with which to think; a truth through which could be productively inflected or with which others could be diffracted (see Chapter 3). As such, I worked towards achieving this

\(^{100}\) As explored in Higgins, Madden, Bérard, Lenz Kothe, and Nordstrom (in review), methodological research “design” often prescriptively and prohibitively continues to act as a signifier that sutures over the signified processes of designing and doing research (Lather, 2007; St. Pierre, 2011a, 2011b). “Design” often signals a method that is exists a priori to research, “a stand-alone, instrumental set of research practices” (St. Pierre, 2011b, p. 52). This also includes and encompasses all of its conceptual apparatus (such as, in this case, “expert” and “expert knowledge”).

Instead, I consider a practice of methodological de/sign to differ and defer that which design comes to signify: design as pre-existing, design as separate or separable from other aspects of research, and design as a means to achieve and justify the ends (see also Derrida, 1976; Spivak, 1976). Because methodological fabric is also a fabrication – a performative and non-separable enactment of the interconnected space between theory, practice, and ethics – methodological design is always already open to be deconstructed and re(con)figured (Barad, 2007, 2010; Lenz-Taguchi, 2010).

This is of significance in spaces of de/colonizing education. Highlighting the ways in which the disciplines discipline what counts as knowledge and, more to the point, knowledge production processes, Smith et al. (2016) ask, “are methodologies simply new technologies of cultural assimilation?” (p. 133). To (re)open the conceptual apparatuses of methodology allows for the possibility of addressing lingering colonial referents.
through three interconnected rounds of tinkering: before, during, and after. Before, I tinkered with the content of the expert interview. During, the expert interview tinkered with itself in its enactment. After, I tinker with the (re)presentation of the expert interview by pulling from insights generated through the theory-generating exchange.

5.2.1 Before: Tinkering with/in expert interview content.

When designing the series of expert interview questions (see Appendix B, C, and D), the original intent was to create a three-part expert interview series that would differentially represent three major themes or threads that were being pulled through Dr. Apffel-Marglin’s 2011 book *Subversive Spiritualities*. Namely, these themes were: a) her methodology of reverse anthropology; b) working within and against Cartesianism, and lastly; c) working beyond Cartesianism by considering the spaces of ritualized enactments. In other words, the interviews as designed were not to repeat that which was already there, but rather tinker within the already existing narratives in Frédérique’s book to connect differently, more loosely, to allow for the possibility of something else to emerge.

This began with the notion that despite the cohesive and complete appearance of the narratives within her book, like any and every text, they were and continue to be open to being tinkered with/in\textsuperscript{101}. Consisting of loosely assembled partial, situated, and relational meanings, any and every narrative is but a series of meanings that are held together by “scandalous sutures” (Derrida, 1976): what Spivak refers to as the “rage for unity” (Spivak, 1976, p. xvi). Thus, narratives are always already open to being irrupted, ruptured, and torn asunder in order to differentially sequence its frayed and fraught meanings to produce new narratives which, in turn, never achieve unity. Thus, when I was developing the questions for the interview that is featured within this chapter (see Appendix C), I centered her work on the entangled political, economic, religious, scientific, and military practices that led to the birth and operationalization of Modernity within Western Europe. I gripped and pulled at these threads from within chapters 2, 3, 5, 6, and 8 in her book *Subversive Spiritualities* to (re)constitute a narrative around this theme. However, in practice, this narrative was never fully achieved either, as the very practice of expert interview exceeds itself to produce something that is within and beyond the narrative framework available to it.

\textsuperscript{101} Such a tinkering can be understood both as tinkering within the narrative presented throughout her book, but also tinkering with it in relation to the multicultural science education debate.
5.2.2 During: Expert interview tinkering with/in itself.

In practice, expert interviews come to be an enactment or practice that is and is not its research design: both the expected and the unexpected come into proximal relation to deesign any possible expert interview methodology design. The arguments that scholars make in interviews are always situated within a real and/or imagined scene of address: what is said, what can be said, and how it is said is always in part produced and producible in relation to the audience to which it is intended as well as the constellation of concepts which are entangled with/in (see Chapter 3 on the prism; see also Butler, 2005; Kirby, 2011). To elaborate upon this point, Judith Butler in an interview with Vicky Kirby speaks to how possibilities of ever shifting cultural and natural norms dis/allow modes of being critical:

I think perhaps mainly in gender Trouble I overemphasize the priority of culture over nature... At the time of Gender Trouble, ... it seemed to me that there was a cultural use of 'natural' arguments to provide legitimacy for natural genders or natural heterosexuality. But that criticism did not take into account of a nature that might be, as it were, beyond the nature/cultural divide, one that is not immediately harnessed for the aims of certain kinds of cultural legitimation practices (Butler in Kirby, 2011, p. 93). 102

Expert interviews are then a site for things to be thought anew, albeit not for the first time, within a differing web of relationships that comes to bear with differing intensities.

At the Sachamama Center in Peru, where the three interviews of roughly two hours with Frédérique occurred, each interview became an opportunity for something that was and was not Subversive Spiritualities. Dr. Apffel-Marglin and I, but her moreso than I, narratively pulled at the anticipated threads differently in order to make new meanings: that which was already came to be in new relations by differentially centering how they were included or excluded, and to which degree. While the questions generated were derived from her book, this did not constrain the interviews, especially towards the end of the interviews. The expert interview alternated from being within the script, to being exceeded by the script, from being an expert interview to a dialogue in which I was also a participant (i.e., what Bogner et al. (2009) refer to as a “quasi-expert”). This participation was nonetheless shaped by the relational elsewheres and elsewhens that exist within and beyond the interview (e.g., Frédérique’s reading recommendations might be an inflection of a teacher-student...).

102 Butler’s criticism of particular cultural uses of “natural facts” still stands today as “natural facts are always informed by cultural bias” (Kirby, 2011, p. 94). As this is “one of the most important contributions that scholars such as Butler have made, ... any return to the question of Nature will need to accommodate such insights rather than put them aside” (p. 94). Nonetheless, the opening of other possibilities beyond the natural/cultural divide allowed by this minor concession sees productive uses in her later work (e.g., Butler, 2010); with an always present cautionary note against the “seductive slide that conflates representation, models, and signs that substitute for material objects, with the objects themselves” (p. 74).
relation held in other spaces). Furthermore, comfortably seated outside her modest abode within the Sachamama center, Frédérique and I were also often audibly joined by other members of the ecology of relationships that shaped that place: the birds chirping, the dogs barking at one another through the nearby fence, the traditional Peruvian three-piece band practicing down the road, the wind, amongst other things. These other-than-human beings that she refers to so often in her book *Subversive Spiritualities* were not simply metaphorically signified and absent, but were rather physically present and active agents in the production of the interview (see also Barad, 2007, 2010; Cajete, 1994, 2000).

5.2.3 After: Tinkering with/in expert interview (re)presentation.

As the interview with Dr. Apffel-Marglin presents a partial, situated, yet rich and nuanced account of how Cartesianism is produced and produceable, the interview itself invites other ways of being (re)presented within, against, and beyond Cartesianism. Accordingly, I turn to Barad (2007)’s post-Cartesian extention of diffraction as metaphor for methodology to inform how I work with Frédérique’s interview.

Recall that for Barad (2007), diffraction asks us to consider where the agencies of observation begin and where they end, what is included, what is excluded, what matters, and what comes to materialize. Important to note here is that, for Barad (2007), the experimental apparatus through which any phenomena manifests is never simply a material tool or a discursive concept, but also includes multiple material and discursive agencies of observation, and extends to include each of their respective material and discursive historicities. This network of bodies of meaning and matter become the experimental apparatus through a differential enactment of the norms of bodily production. As such, these bodies do not simply inter-act between one another, but rather intra-act within this re(con)figured body which is the experimental apparatus. Lastly, through intra-action, materiality and discourse, the domains of ontology and epistemology, are not mutually exclusive but rather co-constitutive. Or, as Barad (2007) states “phenomena are differential patterns of mattering (‘diffraction patterns’) produced through complex agential intra-actions of multiple material-discursive practices or apparatuses of bodily production” (p. 140).

Diffractive methodology is thus a practice of knowing-in-being with/in the production of patterns of difference that emerge when two or more phenomena, or entangled bodies of matter-meaning, are read through one another (Barad, 2007). This is in stark contrast to the optical metaphor of the mirror that operationalizes the production and reproduction of sameness through
representationalism. Diffractive methodology is a process of producing, and being responsive and accountable to non-negligible patterns of difference that come to matter when two or more entangled material-discursive phenomena are diffracted through one another. This requires however that “we learn to tune our analytical instruments (that is our diffractive instruments) in a way that is sufficiently attentive to the details of the phenomenon we want to understand” (p. 73) and to pay attention to the fine details that would otherwise be considered negligible with/in conventional scientific and social scientific research methods. Barad (2007) poses diffractive methodology as an engaged and enacted ethico-onto-epistemological research stance that takes seriously the entanglement of ethics, materiality, and discourse as well as the patterns of difference that emerge through their ongoing diffractive intra-action.

Here, diffractive methodology comes to inform the ways in which the ways in which Dr. Apffel-Marglin’s interview is read through the multicultural education debate to produce patterns of difference that might come to inform how science education might be thought otherwise. Particularly, as diffraction is about producing differences that matter, there is an emphasis on what it means to be accountable to and for ontologically positioning science with/in Cartesianism. With/in any diffractive methodology, Barad (2007) reminds that:

We are responsible for the cuts that we help enact not because we do the choosing (neither do we escape responsibility because “we” are “chosen” by them), but because we are an agential part of the material becoming of the universe (p. 178)

One such set of cuts enacted herein are the editorial cuts which come to produce the textual presentation of the work as expert interview. In producing the text as an articulation of (quasi-)expertise (e.g., expert as rational subject), many agential engagements have been excised. These include, but are not limited to, the now-absent presences of other-than-humans (e.g., dogs, wind), other humans (e.g., those labouring at the Sachamama center), human-other-than-human hybrids (e.g., Peruvian three piece band, blaring radio), as well as moments in which speech is interrupted by thoughtful pauses, stuttering, stammering, ums and ahs. Both Frédérique and I have engaged in this act of narrative “cleaning” in order to produce a text that might be more cohesive, and intelligible as expert interview, to an audience to-come.\footnote{This can be read as a form of strategically occupying an essentializing space (see Spivak, 1993/2009). However, Spivak (1993/2009) reminds, “the strategic use of essentialism can turn into an alibi for proselytizing academic essentialisms” (p. 4) without the persistent critique of that which is being essentialized throughout, “even when it seems that to remind oneself of it is counterproductive” (p. 4). Where Frédérique’s interview challenges throughout the production of the academic subject of knowledge (i.e., expert), the strategic use essentialism remains nonetheless fraught, being at once medicine and poison.}
Furthermore, the interview that follows is split into four parts. The cuts enacted here are emergent (i.e., a “choice” that emerges with/in relations that extend beyond me; see Barad, 2007), producing rich patterns of resonance and divergence when read through the multicultural science education debate. There is nonetheless a cautionary note that different cuts produce and make possible a different set of meaning-making phenomena, this is but one possible possibility or configuration. Each cut is divided into two smaller parts: the interview with Frédéricie always preceding the later diffractive analysis.

To give a quick overview of content addressed by Dr. Apffel-Marglin, the first cut, *Nature/Culture*, addresses how she understands this dichotomy with respect to her own field of anthropology as well as how she strategically goes about addressing it. The second cut, *Descartes, Boyle, and Newton*, speaks to three important figureheads not only in the development of Cartesianism, but also the ways in which they operationalize it. The third cut, *The enclosure, the double-sided ledger, and the laboratory*, situates Cartesianism with/in the material practices of Western Modern Europe with which it could not be disentangled and which lead to its operationalization. The fourth and final cut, *The modest witness, when One Truth becomes two, and the Thirty Years’ War*, positions the practices of the individual within the scientific laboratory within a larger and uneasy socio-political context.

5.3 *Diffracting an Interview with Dr. Frédéricie Apffel-Marglin: On the (Re)Production and Operationalization of Cartesianism and What it Produces:*

5.3.1 **First cut – Dr. Frédéricie Apffel-Marglin on Nature/Culture.**

M. HIGGINS: Within your 2011 book Subversive Spiritualities, you speak to the multiple dichotomies (e.g., mind/body, male/female, colonizer/colonized) that you are working within and against in order to enact a double(d) reversal of anthropology (i.e., subverting the gaze as well as the concepts, categories, and constructs through which the anthropological gaze operates). Recognizing that to disrupt one binary is to disrupt others that are related to it (see Lather, 2007; St. Pierre, 2011a), one of the key dichotomies that you center in your work is that of Nature/Culture. Could you quickly describe how you understand Culture and Nature within this binary pairing?

F. APFFEL-MARGLIN: I have to preface what I’m going to say by saying that my understanding is totally coloured by training as an anthropologist; so what you are getting is the view that currently still, I could say, operates within anthropology. Anthropology has really made the term Culture what
it is, so I should begin with that. Before anthropology defined the term Culture as we know it today during the turn from the 19th to 20th century, culture was something held by a “cultured person.” This usually entailed people going to the symphony, to the fine arts museum, to classical plays; that is what having culture meant. It is still used like that by people who are not reading anthropology; it is still used vernacularly like that. However, anthropology has democratized the term such that it means that everyone, anywhere in the world, has culture and that anthropologized meaning of “culture” has deeply penetrated our vernacular language. There are no people in the world that do not have culture. It is human to have culture, just as it is human to have language and to speak. Furthermore, language and culture are totally integral to one another.

Anthropology, as a discipline, takes as its object of study Culture. Studying “culture” is what anthropologists do, and the discipline has developed an understanding of Culture as an exclusive dichotomy. By exclusive dichotomy, I mean the following: that Nature is what Culture is not and Culture is what Nature is not. They determine each other negatively. It is very important to understand what that means and why it is significant. Exclusivity means that there is an absolute boundary between the two terms. While there are a plethora of dichotomies that enact a tension between two poles in which things move from one pole to the other relating to each other as a continuum, that is not the case with an exclusive dichotomy. That is a very different kettle of fish. I call the former polarities, or sometimes simply dichotomies, and the latter exclusive dichotomies. While there are exclusive dichotomies as well as plain dichotomies or polarities I reserve the term dualism to refer to exclusive dichotomies. The Nature/Culture exclusive dichotomy can be said to have dominated the field of anthropology.

M. HIGGINS: Within your book, you address the notion that the first term of any dichotomy is dominant over the latter, and that this is achieved and upheld, as you mention through a metaphysics of mutual exclusivity and separation. Usually this entails that the first term is constructed in opposition to the second, making the latter its abject other or its object of lack. What consequence does this bear upon Nature as well as those who are considered "natured" (i.e., rather than “cultured”)? Furthermore, how has this been troubled?

F. APFFEL-MARGLIN: The troubling of the Nature/Culture dichotomy has always been important within the second wave of feminism and beyond. Feminism is an important site for this troubling
because women in the Western traditions, such as Christianity and Judaism (except for the mystical traditions), have been associated with Nature (i.e., defined in opposition to Culture).

Within anthropology, this exclusive dichotomy has started to be troubled around the notion of gender, especially by a wonderful British woman anthropologist, Marylin Strathern. She does this work in her book *The Gender of the Gift* on her fieldwork within Melanesia. That was an early book that really is brilliant in troubling the relationship between gender, Culture, and Nature. Following this, more and more scholars in anthropology have troubled this exclusive dichotomy. Interestingly enough, in feminist approaches to anthropology, there is, from my point of view, a sharp divide between those who reject the troubling of that dualism and those who trouble it. The most well known of those who reject the troubling of the Nature/Culture dichotomy is Sherry Ortner. Ortner maps the relations of male/female onto Nature/Culture. In her widely influential essay “Is Female to Male as Nature to Culture?”, she simply takes it for granted that the Nature/Culture dualism is of the same kind as the female/male one; she assumes that there is such a division and that you can map gender on it.

This gender mapping has been crucial in exploring the Cartesian-Boylian-Newtonian paradigm. This is the work of Donna Haraway and, also extremely importantly, of Shapin and Schaffer on Hobbes and the air pump. So the whole Nature/Culture dualism is completely entangled with gender issues, and debates in feminism. That’s why I was, from day one, deeply and personally involved.

M. HIGGINS: There is often a relationship between different dichotomies that allows the productive tinkering within one to have deconstructive effects within others.

F. APFFEL-MARGLIN: Right.

M. HIGGINS: You’ve begun speaking to this here with respect to the Nature/Culture binary in relation to male/female, what other dichotomies might Nature/Culture be entangled with to produce particular bodies as “natured” and what consequences does this yield?

F. APFFEL-MARGLIN: While I talked about the case of gender, the UR [i.e., original], the basic, fundamental trope or metaphor, even if it is not seen as that, is of Nature to be controlled by Man. I
deliberately use the masculine here because men developed it. They excluded women in that newly minted epistemological paradigm known as Classical Science, an exclusion that continued until the 20th century. It really is Man, the masculine European, Western European male. So if Nature is to be controlled by Man, this also means that all other humans are closer to Nature. We talked about women, but also included within what Judith Butler has called “the abject other” are those perceived as “primitive,” the “savage,” and lower class. Diasporic people, Indigenous people, and other colonized people are often seen as “closer to Nature” because of a perceived inability to control themselves, their biology, or their nature. These tropes are still fully operational in the world today even if not everyone subscribes to them; they unfortunately have not disappeared. In my context of working with the Kichwa-Lamista, the Indigenous peoples in what is now the Peruvian High Amazon, they are often treated as “wild people” who have no civilization or language, amongst other lacks.

M. HIGGINS: In considering exclusive dichotomies, it is always productive to look at both sides of the binary division. If those who are perceived as “being closer to Nature” are being treated in these ways, what does that mean for those who are perceived or self-perceived as “cultured?” How is the Eurocentric, patriarchal and masculine human body, or Man, and his way of being in the world shaped and affected by this exclusive dichotomy?

F. APFFEL-MARGLIN: That’s a lovely question. I’m so glad that you are asking that and I would recommend a book to you. My very good friend Ashish Nandy addresses this topic in his first book called The Intimate Enemy published in 1983. In short, it is about colonialism but it also addresses how colonialism finally hurts the colonizer as well as the colonized. When I heard your question, I immediately thought of Ashish Nandy’s work. About this, I would certainly say that this way of being is one of being déchu [i.e., having lost dignity]. It is an ethical fall from grace, or a form of self-perversion.

M. HIGGINS: Paulo Freire, in Pedagogy of the Oppressed, speaks to a similar notion: to dehumanize the Other is dehumanizing in and of (it)self through a failure to recognize the humanity of the Other.
F. APFFEL-MARGLIN: Exactly.

M. HIGGINS: This very much speaks to the notion that exclusive dichotomies are porous rather than hermetic. If we take the work of Jacques Derrida seriously, despite the prevalence and pervasiveness of this exclusive dichotomy, like other binaries, it is *déjà toujours* or always already deconstructing. In other words, it is never fully achieved as it is a myth or an imaginary. In your book *Subversive Spiritualities*, you explore and leverage some examples within recent scholarship that you develop within your work that speak to the porosity of the Nature/Culture dichotomy (e.g., Cultured Nature and Natured Culture - such as cultural landscapes). Can you speak to why this is important to your work?

F. APFFEL-MARGLIN: I begin with this recent scholarship around cultural landscapes for strategic reasons. Just like the *Gedanken* experiments (i.e., thought experiments) in quantum physics have been empirically proven; the undoing of Nature/Culture has been enacted empirically and you cannot deny it. If you are using the language of the mainstream, it is harder to deny. Because scientists have already shown that the Amazon forest is anthropogenic [i.e., produced through and with human interaction], all I need to do is provide the data to make my point. I start with this because it is an easier way of entering into that topic. It is easier for people who are not inclined to hear your message [i.e., those who might disagree] because you are giving empirical evidence [i.e., and speaking on their terms]. Start where it is very hard to deny: empiricism. Because if I begin with more philosophical discussions around themes people do not want to hear, people close down before I’ve even begun. I have seen that happen in meetings and conferences.

M. HIGGINS: That’s a very interesting strategy that you utilize throughout your book. On one hand, you’re rejecting the universality and the privileging of WMS and its ongoing supersessionism [i.e., the double(d) process of WMS acting as the meter stick against which other ways-of-knowing-Nature are judged, as well the ways in which WMS supplants and displaces other ways-of-knowing-Nature]. On the other hand, you are strategically using that same structure all at the same time.
F. APFFEL-MARGLIN: Right, but only when it is to my purposes. Because of my relationships to people within the mainstream, I’ve learned to use these arguments. But it is important for me not to stay there, and only use it as an entry point to my argument.

5.3.2 First cut – Nature/Culture and the multicultural science education debate.

As Dr. Apffel-Marglin’s segmented interview is diffracted with the multicultural science education debate, it comes to produce particular patterns of dynamic resonance and dissonance with one another around three key nodes: a) Nature/Culture as mutually exclusive dichotomy; b) problematic natural-cultural hybrids (e.g., “naturalized facts”) and, c) productively using natural-cultural hybrids.

The notion of Nature/Culture as mutually exclusive has much bearing on both the fields of anthropology and science. It is the “foundational” cut of Western modernity that puts both fields into dynamic and resonating relationality (Apffel-Marglin, 2011; Barad, 2007; Braidotti, 2013; Latour, 1993, 2004b; Kirby, 2011). As Dr. Apffel-Marglin articulates, the mutually exclusive dichotomy between Nature and Culture can be enunciated such: “Nature is what Culture is not and Culture is what Nature is not” which is further qualified by “an absolute boundary between the two terms.” As mentioned earlier within this chapter, this is deeply entangled with/in the practices of validating what one might consider valid or worthwhile (i.e., “what counts” as science) in terms of meaning-making practices with/in Nature; within this framework, all knowledge of Nature must be made from a mutually exclusively cultural position (see Barad, 2007; Latour, 1993, 2004b). Through patterns of similar differences and different similarities, as Frédérique articulates, meaning-making practices within the social sciences (such as anthropology) are similarly but differently entangled with/in the Nature/Culture exclusive dichotomy. Through the capillary circulation of scientificity, meaning-making practices within the social sciences are often (re)shaped such that knowledge of Culture must be made from a mutually exclusive cultural position (see Apffel-Marglin, 2011; Braidotti, 2013; Lather, 2007, 2010; St. Pierre, 2011a, 2011b).

Recall that Smith (1999/2012) posits that distance is a key organizing concept for understanding how Western modernity is enacted. She expands upon this by stating that distance becomes the enactment of the “specific spatial vocabulary of colonialism which can be assembled around three concepts: (1) the line, (2) the centre, and (3) the outside” (Smith, 1999/2012, p. 55). The dividing line of mutual exclusivity is a (supposed) hermetic safeguard which masks the ways in which the outside and the inside are always already in proximal relation. Within the sciences as well
as the social sciences, one consequence of such a mutual exclusivity is the inability to account for the ways in which Nature comes to bear upon Culture, how Culture comes to bear upon Nature, and an extreme difficulty in occupying both spaces simultaneously (Barad, 2007, 2010; Braidotti, 2013; Latour, 1993, 2004b; Kirby, 2011). Through scientificity, the mutual exclusion of Nature and Culture translated into research practices in which cultural locations of observer and observed could be conceptualized and enacted as separate and separable: discounting the ways in which there is no outside of Culture (Lather, 2007).

With/in the multicultural science education debate, such mutual exclusivity makes difficult even the task of engaging in the question can science (i.e., knowing nature) and justice (i.e., respecting diverse cultural knowledges) co-exist within the science education classroom? As Latour (2004b) reminds us, “the notions of nature and [cultural] politics had been developed over centuries in such a way as to make any juxtaposition, any synthesis, any combination of the two terms impossible” (p. 3, emphasis in original). As explored within Chapter 2, such a dichotomized relationship makes it such that one can ask ethical questions of science or scientific questions of ethics, but never fully arriving at something that effectively straddles and occupies both spaces simultaneously within the terms articulated by both: the production of an ethical science that is the product of both yet still retains sameness. Such is, as Spivak (1976) refers, an infinite dream of plenitude (as the concept of an ethical science would productively exceed conceptions of both ethics and science), it is an impossibility that is nonetheless worth striving for.

The goal of ethical justice-to-come within science education, or a way of knowing nature that can account for or be accountable to its cultural politics, is all the more prescient when considering what Latour (1993) refers to as particular universalism. Recall, as Latour (1993) states, one cultural location always comes to be deemed as the valid location from which to make meaning of nature: that of Man (“the masculine European, Western European male” as Frédérique states)\(^\text{104}\). It has been and continues to be articulated both within the sciences and the social sciences that the Nature/Culture binary has and upholds a Eurocentric legacy (Apffel-Marglin, 2011; Braidotti, 2013; Derrida, 1976; Latour, 1993; Kirby, 2011). As an in-between space, the same has been argued many

\(^{104}\) It is important to distinguish between a Man (i.e., a Western European male), the Man, (i.e., the shadowy figure in Marxist nightmares which appears to control nearly all from behind the scenes), and Man as articulated here. The first two emerge from use of the representational logic of the mirror such that they are representative of an individual, whether real or imagined, who is a separate or separable agent (i.e., what Nietzsche refers to as the “individual of will”) benefitting from the power systems articulated. The latter term speaks to the complex and capillary circulation of ways-of-knowing-in-being that uphold and operationalize systems that center Man and Western modernity (e.g., Eurocentrism, anthropocentrism, patriarchy).
times over that the multicultural science education debate is one that, at its very roots, operates within and against the bounds of Eurocentrism (Aikenhead & Michell, 2011; Lewis & Aikenhead, 2000; McKinley, 2000; Sammel, 2009); an entangled part of the whole that even some scientists are beginning to comment on (e.g., Mazzochi, 2006, 2008). Lewis and Aikenhead (2000) summarize Eurocentrism as “the idea that the people, places, and events of Western European cultures are superior and a standard against which other cultures should be judged” (p. 53). Within this debate and similar others in which epistemological claims are being made across cultural contexts, it is important to consider both the relationships, and the processes of translating, between cultural spaces (see Aikenhead & Michell, 2011; Belczeweski, 2009; Carter, 2004; McKinley, 2000; Sammel, 2009). This becomes all the more pressing when the West is included within this act of translations as:

Eurocentrism is the colonizer’s model of the world in a very literal sense: it is not merely a set of beliefs, a bundle of beliefs. It has evolved, through time, into a finely sculpted model, a structured whole; in fact a single theory, a general framework for many smaller theories, historical, geographical, psychological, sociological, and philosophical. This supertheory is diffusionism. (Blaut 1993, pp. 10-11)

As James Blaut (1993) explains, through this diffusionist model of dissemination, Eurocentric modes of thought center themselves and propagate, all the while subjecting, assimilating, and subsuming other modes of thought (see also Battiste, 2005). “Universalism”, which is one of the many faces or applied strategies of Eurocentrism, is achieved through diffusionism and the ways in which Western knowledge comes to be positioned against other systems of knowledge as the norm. Within the multicultural science education debate this relational positioning produces “the implicit curriculum message... that the only science is [W]estern science” (Hodson, 1993, p. 686, emphasis in original).

This becomes all the more complex when considering that Nature/Culture as a mutually exclusive dichotomy that is but one ontological configuration amongst many, as explored earlier with this chapter. As Latour (1993) reminds, the Nature/Culture binary is never fully achieved or achievable. “We Have Never Been Modern” as the eponymous title of his book proclaims. There have always been natural-cultural hybrids existing in the space(s) between Nature and Culture as the result of the ways in which Nature and Culture always already flow into one another: we are always already in a space of account-ability towards and for the ways in which ontological configurations (e.g., Nature/Culture binary) coalesce with epistemology and ethics (e.g., particular universalism). Science and science educational spaces are not exempt from this occurrence. While some are problematic and some offer productive possibilities, when the world is conceived of and enacted
through a mutually exclusive binary, ways-of-knowing nature cannot account for or be accountable to natural-cultural hybrids.

As Dr. Frédérique Apffel-Marglin spoke, one of the greatest consequences of the “particular universalism” (Latour, 1993) through which science endeavours to mirror Nature from its cultural location is that some bodies are proclaimed as being “closer to Nature.” Such “naturalized facts” come to be a double(d) diminishing: the ways of knowing articulated from these positions are denied validity (see Chapter 2), such as TEK and IWLN, as they fail to achieve the normative and “necessary” criteria of distance through which a mirroring of nature is achievable (see Chapter 3); but furthermore, it is to deny the humanity of Man’s “abject other” (e.g., Indigenous peoples, women, etc.) as it relies upon a conception of Nature (i.e., ontology) as static, uniform, and unflinching such that Man’s “abject other” become but uni-dimensional people (see McKinley, 2000, 2007; Sammel, 2009).

Within other fields, responses to “naturalized facts” have been to reverse the Nature/Culture binary or to abandon Nature altogether. However, such anti-ontological stances that circulated with the social sciences with a bit more ease (e.g., “too simple” readings of Butler’s *Gender Trouble*105) would not find a welcome, frequent, or widespread home within the sciences and science education despite their overlapping spaces of meaning-making (see Barad, 2000, 2011). The reversal of the resident hierarchy between Nature and Culture would not suffice or be viable to many within science education. This can be attributed to the holding and being held by knowledge of nature as separate and separable from cultural politics, often times antagonistically; they are most commonly defined and enacted through a mutually exclusive Nature/Culture dichotomy (Latour, 2004b). For many scientists and science educators, the false binary choice of renouncing science to strive for ethics produces an unintelligible scientific subject. These continue to complicate questions of accounting for and being accountable to Culture (or even culture) in the process of meaning-making with Nature.

However, as Frédérique Apffel-Marglin posits within the interview, and as explored within the Chapter 2, not all in-between positions need to be antagonistic. There are productive

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105 As Colebrook (2008) suggests, Butler’s *Gender Trouble* is often (too simply) read as anti-ontological as it resituates that which is problematically enacted as biological determinism (i.e., sex) into the realm of discourse (i.e., through gender performativity). Taking a cue from Foucaultian critique (see Chapter 3), it is fair to state that Butler does not wholly jettison ontology altogether, but rather ontology *like that* (i.e., a Cartesian ontology in which matter precedes meaning). In turn, Colebrook’s (2008) reading of Butler suggests that materiality (i.e., ontology) emerges as co-constituted by discourse (i.e., epistemology), subverting dominant epistemological and ontological constructions and enactments rather than negating them.
intermediary positions that can operate simultaneously within and against such that it productively retains a degree of intelligibility and desirability. Thus, speaking to productive natural-cultural hybrids, recall that deconstruction is a two-part process which must necessarily begin with the reversal of the hierarchy but must then undo the hierarchy altogether by paying attention to the moments in which the hierarchy altogether vacillates between its constitutive terms. Dr. Apffel-Marglin’s quick but incisive pointing towards her work, (see Apffel-Marglin, 2011) and that of others, with regards to anthropogenic (or cultural) landscapes opens up productive natural-cultural locations on terms that act as an invitation to dialogue rather than a dismissal. In other words, as anthropogenic landscapes are within the realm of scientific discovery, they cannot be so easily dismissed as being “antagonistic” cultural politics (e.g., in the case of the critical reversal of critiques of “naturalized facts”; e.g., Siegel, 2001), and furthermore act as an invitation to reconsider the very terms under which science operate within the very linguistic practices that science utilizes: it is a critical inhabitation.

Continuing this critical inhabitation, Dr. Apffel-Marglin begins to articulate in the following sections, the way in which the Nature/Culture mutually exclusive dichotomy (i.e., what is traditionally referred to simply as “ontology”) is not something that strictly is or is not but rather in a state of ongoing becoming by highlighting processes and peoples involved in its operationalization.

5.3.3 Second cut – Dr. Frédérique Apffel-Marglin on Descartes, Boyle, and Newton

M. HIGGINS: Within the Nature/Culture dichotomy, even as it always being produced anew through a continued entanglement with other binaries such as masculine/feminine, one of the common threads being pulled through is dualistic thinking. While the origin of dualistic thinking (if we can say there is one) is largely, and often, attributed to René Descartes, you extend this to also include the 17th century scientific revolution as well as the work of Robert Boyle and Isaac Newton. Why are these three key figures in the production of what is often referred to as a mechanical, clockwork universe, as well as dualistic thought?

F. APFFEL-MARGLIN: First, I want to preface this by saying that the new (new of course in the 17th century) Cartesian-Boylan-Newtonian paradigm, has of course much deeper and wider historical roots. In my book, when I discuss representationalism [i.e., the epistemological and ontological web of concepts and categories enacted and operationalized through representation], I go all the way back to Plato and the Greek alphabet. So there are deep roots that are entangled within
the Cartesian-Boylian-Newtonian paradigm, even if you stick with the birth of modernity. Not as deep as Plato, but certainly a few centuries preceding the scientific revolution. Of course this is simplifying it. Nevertheless, there is something very special and key about these three. They might not have created it whole cloth [i.e., entirely responsible for its fabrication] but it would not have had the power, particularly the persuasive power, were it not for those three because at the time it was a highly debated and contested new paradigm.

Descartes was the first philosopher of materialism. He was very systematic in his approach to establishing res cognitans [i.e., epistemology] and, by extension through separation and mutual exclusivity, res extensa [i.e., ontology]. So Descartes is writing in the early 1600’s, and most of his writing is around 1620-1630 and he died in 1650. Descartes was a philosopher, so he is making a thought structure; he systematized this philosophy before Boyle comes along.

Boyle is mid 17th century (i.e., 1650’s). He is doing his experiments with the air pump but he probably only started in the 1640’s; for him the key period are the 1650’s. Why is Boyle important? Boyle operationalizes Descartes. How did Boyle do this? He creates the laboratory, the modest witnesses, and a literary technology, as Shapin and Schaffer have brilliantly shown. He is important because he invents these practices that constitute the scientific experimental method. How key can you be? He is operationalizing Descartes’ systematization of thought by making it work in action. Boyle was an actor in the creation of the *The President, Council, and Fellows of the Royal Society of London for Improving Natural Knowledge*, also known as the Royal Society. He did this because he had to. At the time, universities were a monopoly of the church; this new knowledge had to happen outside. At the same time as the Royal Society, there was also an Italian academy, as well as *l’Académie Française* started by Mersenne and Descartes. However, within a few decades, the Royal Society quickly became the dominant academy of science as the king of England was funding it. To open up a new academic space outside of the church was absolutely key when it came to operationalizing Cartesian materialism.

Why Newton is so important is because he brought together Descartes and Boyle by establishing the mathematical relationship between Descartes’ philosophy and Boyle’s practice [i.e., through what is commonly referred to as Newtonian physics today]. Canonically, the age of the scientific revolution is seen as starting with Copernicus mid-16th century with his *On the Revolutions of the Heavenly Spheres* that was published posthumously in 1543. Newton, with his *Principia Mathematica* in 1687, just clinched it. He was absolutely brilliant, and also very powerful. He was
lionized. He is buried where the kings are buried in England. He was the most famous man of his time. He had advised the king and he had enormous power, power that he nurtured very carefully. He knew perfectly well, that there were certain things he could not make public, such as his engagement in practices of hermeticism [i.e., non-Cartesian Western ways-of-knowing-Nature which blended scientific practices with “magical” ones such as alchemy and astrology]106.

5.3.4 Second Cut – Descartes, Boyle, Newton, and the multicultural science education debate.

From Dr. Apffel-Marglin’s critical inhabitation of a historical narrative of modernity, what we begin to see emerge here is that Cartesianism is not something that is but is rather becoming. As van Eijck and Roth (2007) remind within the context of the multicultural science education debate, it is important to consider science not as knowledge but as knowledge-processes that are highly contextualized and situated. One such consideration for Cartesianism as becoming rather than being is to refuse its frequent positioning as naturalized within an ahistorical present (see Spivak, 1999). However, even if we trace its historicity, it cannot simply be referred to as knowledge originating from and obtained by René Descartes that, as the truth, mirrors metaphysics. Rather, it is a knowledge-process that is without an origin (e.g., Plato): its meaning and matter are always deferred and differing such that it forms an ongoing citational chain (see Barad, 2007, 2010; Derrida, 1976). Cartesianism, as Dr. Apffel-Marglin explains, is not created “whole cloth” by René Descartes, nor by Thomas Boyle, or Isaac Newton: Cartesianism is something that precedes, lives alongside, and outlives all three through its circulation and differential enactments across a multiplicity of spaces. Nonetheless, these three do come to be key actors in the operationalization of Cartesianism such that it is widespread, common place, and “common sense;” something one has and by which one is had (see Barad, 2007; Higgins, 2014a).

Diffracting Frédérique’s account of Descartes, Boyle, and Newton with and through the multicultural science education debate again reinforces the notion that the Nature/Culture mutually

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106 Frédérique Apffel-Marglin shared the following regarding what Newton had to forego to maintain epistemic power and privilege within his geo-temporal contexts:

> It was just delightful for me to learn of that, by reading Isabelle Stengers’ little play about Newton titled *La Guerre des Sciences aura-t-elle lieu?*, that one of Newton’s descendants needed money in 1930 and found in Newton’s attic unpublished papers, manuscripts, and other works. He auctioned them to make money. So it was then bought and studied. This work was spiritual in tone: gravity was a spiritual power. Of course, he could not go public with this. So it was not to be found out or made public until these papers were sold and people took time to study them.

It could be stated that this is yet another rich example of how science, or ways-of-knowing-Nature are always already entangled with/in and pristamically producing the norms of articulation (i.e., what can be said and done, and what cannot).
exclusive dichotomy is but a configuration amongst many and that it is an onto-epistemological enactment that we are responsible for; even if, as Barad (2007) states, we choose and are chosen by such configurations (see also Butler, 2005; Higgins, 2014a). However, what significantly begins to resonate with this vignette is that Cartesianism, when considered through distributed agency (Barad, 2007), can be considered as a “regime of truth” (Foucault, 1977, 1979). In other words, through their respective metaphysical framework, laboratory practice, and mathematics, Descartes, Boyle, and Newton implicitly enact theory-practices that implicitly come to support one another. As Foucault (1979) explains, “‘truth’ is linked in a circular relation with systems of power which produce and sustain it, and to effects of power which it induces and which extend it” (p. 47). The example at the beginning of this chapter could be stated as a singular application of such a regime of truth: Cobern and Loving (2008), in their argument for (re)considering and supporting an epistemology of “epistemic realism,” pivot and side-step to “ontology” (read: singular; i.e., Cartesianism) without being accountable to or for the ways in which the two share a co-constitutive onto-epistemic relationship. This is often the case when and where it comes to the defense of WMS as the way of knowing nature: these diverse knowledge claims which come to reinforce WMS almost always operate through the differing similarity through an implicit assumption that Cartesianism is the (only) ontology. It is no surprise, as Dr. Apffel-Marglin continues to expand upon this, that Cartesianism comes to be (re)presented as “common sense” as Cobern and Loving (2008) define it; holding the ahistorical appearance of stability, neutrality, and normality.

Furthermore, as indicated here and expanded upon within the next section, knowledge and power share a co-constitutive relationship and important role in the dispersal of such knowledge-practices (Foucault, 1977, 1979). For example, the footnote regarding Newton’s dual positioning with respect to modern science and hermeticism reveals Newton to having, and being had, by power. He is being produced as a scientific subject that simultaneously upholds and is upheld by systems of power. However, as discussed in the following section, such a dispersal of knowledge-practices comes to bear at a larger scale when considering the technologies which operationalize this way of knowing-in-being (e.g., the enclosure, the double-sided ledger, and the laboratory).

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107 Furthermore, while Newton’s subject position is produced by the there-then of the time and place, knowing Newton as scientist cannot be disentangled from the entangled here-now
5.3.5 Third cut – Dr. Frédérique Apffel-Marglin on the enclosure, the double-sided ledger, and the laboratory.

M. HIGGINS: While we are on the subject, within your book, you make clear that “the scientific revolution was not the result of decades of discoveries, but was in the making for centuries” (Apffel-Marglin, 2011, p. 33). While ideas and ways-of-thinking, like the Cartesian-Boyleian-Newtonian framework, are always being (re)generated, those that “stick” (and stick around) are those that are operationalized and become embedded within the matrix of power/knowledge. It is important to speak of Descartes, Boyle, and Newton when tracing or retracing the production of the Nature/Culture exclusive dichotomy, as they were key players in making operational this dualism. However, this is not to say that the scientific revolution to which Nature/Culture is often attributed origin was not entangled with and in the social, political, religious, economic and other events, tensions, and forces that were happening at the time as well as the time which preceded it. Could you give a thumbnail account of the state of the European subject historically around and preceding the “tipping point” of modernity [i.e., the scientific revolution]? 

F. APFFEL-MARGLIN: There’s two ways I can answer that question. I could answer it in terms of the forces that killed hylozoism [i.e., a Western European relational way-of-knowing-in-being of the time premised around the notion that all matter is in some sense alive; shares a relation with hermeticism] and made what Descartes or Boyle called the molecular or atomic model of the world, and humanistic/materialistic dualism the dominant and winning view.

Another way to answer this question is to go historical and speak to the history of the fall of the manorial system, sometimes called the feudal system, and all the conflicts that emerge. I have to preface this by saying that I owe a serious intellectual debt to my ex-husband Stephen Marglin’s work, as he’s done a huge amount of historical work on the birth of capitalism. Drawing from literature on economic anthropology, historical economics, and such works, I have come to the view that the enclosure movement is associated with the birth of Cartesian dualism. What I argue is that it is that economic context of the emergence of mercantilism, which isn’t yet capitalism, but rather proto-capitalism. It is a proto-market economy that comes to replace the manorial system that begins with the enclosure of the commons. The enclosing of the commons started in Western Europe, continued through colonialization, and now persists through globalization. It is incredibly relevant when you’re dealing with Indigenous peoples, places, and protocols as this enclosure movement has
continued. The enclosure of the commons is for me the key thing that gives the social, political, and religious context that gives credit and credence to Descartes’, Boyle’s and, Newton’s intellectual work and makes it stick.

M. HIGGINS: As you state in your book *Subversive Spiritualities*, understanding the enclosure movement and the encloser’s advantage are important in setting the stage for and are entangled within the operationalization of the Nature/Culture dichotomy. Could you speak more to this movement and its consequences?

F. APFFEL-MARGLIN: At the time of the enclosure movement, there was a lot of conflict. It was a time of peasant wars in France and in England. There was tremendous social and political conflict. However, the enclosure movement was simply a power play.

This plays out similarly today: governments in the global South are currently signing the Free Trade agreement with the United States in which the small print says that you have to make land available to businesses, that land being the commons for Indigenous peoples. Because Indigenous peoples don’t have title to it, the governments can say “no, we’re giving it to the oil companies, the mining companies, the timbering companies, the agri-chemical companies, etc.” That is currently what is going on, and it is going on everywhere in the global South.

This is what happened, first in England, France, and a few other countries in Western Europe. The rich powerful merchants simply bullied others to get their way through the local courts. Because they had money and connections, they could make it stick. They gained title to the land, and then they actually put up a fence: that’s what enclosure means. So you put a fence, and say: “this is mine.” Then you use the land as you see fit. At the beginning, it was because the price of wool cloth went up and the world was trading wool cloth, so they wanted to get into that trade by raising and pasturing sheep. So they simply bullied everybody with the support of the aristocracy because many merchants were aristocrats. They made it stick legally through the courts but also through direct violence.

M. HIGGINS: One of the things I appreciate in this discussion and in your book is that the enclosure is not only a figurative or epistemological form of separation but rather or also one that is literal and material. Part of this comes into play in your exploration the enclosure as an enactment through the
calculation of the encloser’s advantage in which you make clear that the calculation not only exerts power following its enactment, but also through its enactment; the calculation itself and that which is entangled with/in it is important.

F. APFFEL-MARGLIN: This is directly related to the beginning of banks. I’ve fallen by chance on this while exploring the history of mathematics. In my discussion of the whole history of mathematics within Subversive Spiritualities, an important moment is when one becomes a real number. One is what you use for counting; when one becomes a number, it creates a new category, that of magnitude.

The first banks emerged in the great merchant cities of Italy. The Latin word ratio, while I didn’t do the philology [i.e., the study of language in written historical sources located between history and linguistics] of it, I understand it to mean double-entry book-keeping from its use at the time. It also bears a relationship to rationality. Ratio becomes rationality: that’s the way it is born. The double-entry ratio-based calculation [e.g., quantifiable equivalencies], that’s what makes rationality possible.

To calculate one’s advantage, you have to remove yourself. Remove yourself from the land and the community. The people and the land are no longer one thing, belonging to each other sharing and living together. If you go into Indigenous communities, people usually do not calculate like that, even among small farmers in India. That’s where I first encountered it. In the Indigenous communities here (Peruvian High Amazon), it’s glaring: no one calculates in these ways. You do things to live and to regenerate life.

It goes together with my argument about the Burning Times when they exterminated hylozoism, hermeticism, alchemy, and various other ways-of-knowing and -being. The peasants, the so-called witches, and the so-called magicians were very close with each other and constantly sharing knowledge through contact with each other. Therefore, calculating the encloser’s advantage has political, economic, social, and spiritual consequences. They are all entangled.

The mutually exclusive Nature/Culture dichotomy has its birth in removing the people from the land, and using the land as an economic asset. Land becomes a thing, an object on or through which, depending what you do with it, one generates an economic profit based on and derived through calculations of an advantage accruing to a single (male) owner and along with it excluding the other members of the land, the non-humans, the other humans in the community and the other-
than-humans, namely the earth beings. Advantage was the term that they used at the time. This is the beginning of the end.

M. HIGGINS: Could you speak further to the consequences of the enclosure movement for those who were unwillingly entangled? What did this mean for those who might not have had the privilege of being an encloser?

F. APFFEL-MARGLIN: The herbalists, like Indigenous peoples and their relationship to Land, depended on being able to live in the forest and knowing the forest very well, its animals and plants, in order to know how to heal people. However, once the commons were enclosed, they were no longer allowed access. They could not continue their practice. The church backed the powerful by calling the commoner women witches, and by calling them heretics. At the end of the 15th century, in 1484, the Pope in Rome declared witches to be heretics. If they could be proven to be witches, they were to be burned. This was the Burning Times. Witches, however, had always existed, why declare them heretics at the end of the 15th century when they had always been around? The short answer is that they were no longer tolerated. I argue that the main reason why the inquisition set on them at that particular time in history is to be correlated with the enclosure movement.

At the time the process of enclosing the commons was going on hylozoist experimenters and Cartesian-Boylan experimenters were having debates. When discussing enclosures, you had those who were criticizing and those who were defending this practice. Critics and defenders could be from the same class; it depended on one’s politics. But not unlike today, those who defended the enclosure tended to be landowners: wealthy merchants and aristocrats. While there was this tendency, you cannot say ‘always’ here because people did not always act according to their class.

It is not unlike what’s going on today in the Global South in general. Recently, in Bagua, Peru, a similar debate was public. It was amazing to see that everyone who was criticizing the enclosure of land professed that everyone has a right to the commons. That is the meaning of a commons, belonging to everyone. The vulnerable, the old, the widows, those who are unlucky, and etc. are assured of their daily bread; they can live because they have access to the commons. The calculation of the encloser’s advantage begins with the enclosure of land and thereby making land an exclusive property of the encloser.
I’m now writing for an encyclopedia of Hinduism on how food was seen in pre-colonial times in India. Everyone has a right to life by virtue of being born: that is how the polity [i.e., local government] was organized, and how people behaved. If you are alive, you deserve to eat. What emerges through the enclosure of the commons is that you eat only if you work earning wages with which to purchase food which implies the associated need of creating labour as a commodity. You have to sell your labour because it is the only way you can access food. Selling one’s labour requires a previous transformation which consists in owning your individual body whose labour power is something that you can sell because you are its exclusive owner. Before the enclosure movement, and in today’s Indigenous and small peasant societies, your labour is not something for which you get paid. Instead, your neighbours and your relatives get together everyday and work on your land and tomorrow you’re going to work on their land – that kind of principle. You can extend it to other and bigger things, but that is how people do things; labour is not a commodity or something you sell.

M. HIGGINS: The creation of the body as labour speaks to the operation of what Karen Barad (2007) refers to as a “metaphysics of individualism”. In other words a body, be it human, other-than-human, or more-than-human that is separate and separable. This, as you state, disrupts relationships of community between human, non-human and other-than-human. Could you elaborate more on the notion of closure and boundedness of the human body and how it ties into this separation and separability?

F. APFFEL-MARGLIN: The non-porous body bounded by the skin is necessary for the emergence of labour as a commodity because you have to own your body, its power and its force, in order to sell it. The body as a biological bounded separate entity that you own so that you can sell it implies a capitalist market economy. Labour is, according to Karl Polanyi, one of the three forces of production [i.e., land, labour, and capital], without which you would not have capitalism.

If you insist on the biological boundedness of bodies and you teach that to kids, you implicitly reproduce the capitalist mode of production. This entails a devalorizing of the commons and what I call the cosmocentric economy, the exchange of gifts within the human, non-human and other-than-human communities and everything that these represent. Accordingly, it is a statement that Indigenous and rural peasant people are backwards and superstitious, while simultaneously opening a wide space for the entrance of a profit-motivated market economy. This closes the door to
non-modern ways of life in which the commons are central. Not only commons as land but its web of interconnected commons: food as commons (i.e., one person starves, everyone starves; one person eats, everybody eats), water as commons, air as commons, knowledge as a commons.

M.HIGGINS: In your book, you speak of this with respect to the spirit of the gift and communal labour. It is not the measuring or quantification of labour that is important but rather it is the act of coming together and working towards common goals that is important.

F. APFFEL-MARGLIN: Exactly, and you can extend that. The labour is not only to cultivate the neighbour’s field or your relative’s field, but it is also for festivals. In medieval Europe, all the cathedrals were built that way. All the non-modern great works, like the pyramids in Egypt and in meso-America, they were built in that way. It was not paid labour because there was no labour as a commodity; you do it for the community, not only of humans but also for the non-humans and other-than-humans.

Accordingly, there are important ties between labour as commodity and land as commodity. Through the enclosure of land, land emerges as a commodity. Becoming private property, you can buy and sell land because it belongs to somebody. It is the same thing with labour as a commodity. It makes the body a form of property. You own your body; and because you own your body, you can sell your labour power on the market.

It’s a profound transformation. However, it took a long time to change the habits of people, to make people develop the habits necessary to create labour as a commodity within these new norms. Nonetheless, because labour as a commodity is an abstraction, this profoundly transformed the sense of what a person is and can be.

Schooling plays an important and ongoing role with this. It was and is through schooling, especially early 19th century and the end of the 18th century during the period when schooling became obligatory, that you learn the disciplines necessary to sell your labour power. In many Indigenous communities, you typically did not or do not do this. The transitions that occurred during the modernization of Western Europe continue to be relevant today, even if these transitions happened in other parts of the world at another time.
M. HIGGINS: This is certainly a double(d) form of disciplining bodies within schools. Students are not only learning the disciplines (e.g., sciences, arts), but also learning as a form of discipline in and of itself.

F. APFFEL-MARGLIN: Of course, through many bodily cues: the bells which reinforce punctuality and a disciplining of time, bodies sitting at a desk in a row of desks for so many hours engaged in mental focus, all of these things and more.

M. HIGGINS: Foucault’s *Discipline and Punish* does a terrific job of unpacking the normative organization of bodies within systems of schooling and the modernist values at play there.

Directly related to this is the question of Boyle’s laboratory. While Descartes is often attributed dualistic thought (i.e., cogito ergo sum), you state that it was Boyle who operationalized it through his “technologies” of the scientific laboratory. What did these entail and how did this work towards the operationalization of the Nature/Culture binary?

F. APFFEL-MARGLIN: I have to preface this by stating that Boyle used to be an alchemist, which is a form of hylozoism. But, in the transition to the laboratory, he shifted from a hylozoist practice to a dualist one. The work of Elizabeth Potter is key here because she shows that he was a big landowner. He was politically motivated by the possibility of losing his land. That’s the beauty of this kind of work. It shows that the scientific method and the experimental scientific method had everything to do with politics, economics, and religions of the time and place.

Getting back to your question, this is pure Shapin and Schaffer and the work they do in their book *Leviathan and the Air Pump*. In their work, they identify three technologies which I mentioned earlier. One was the creation of the laboratory. Prior to the scientific revolution, the hylozoist or hermeticist (known under the more general term of “occult philosopher”) worked in private in a secret cabinet. There he did all sorts of alchemical experiments, as well as other kinds of things. He would use a variety of instruments to conduct experimentations. However, a crucial shift was when the lab became a public space. Why did it have to be a public space? For several reasons; one of which being that by making it a public space you are stating that you are not an occult philosopher. Making the laboratory a public space is equivalent to declaring that “I’m not an Occult Philosopher”. While it was still a choice to be a hylozoist at the time since there were active debates at the time
between hylozoists and mechanicists, the hylozoists were still being persecuted by the inquisitions of both Protestants and Catholics. Second, it had to be public in order to establish what Shapin and Schaffer call the social technology.

This second technology, the social technology, was utilized to establish the facts, which was called the “matter of fact” or the scientific fact, within the laboratory. The model for this system being the court\(^\text{108}\), and the court being a system of witnesses, facts would be established through witnessing. To do this, you had to have witnesses to the experiment and have a discussion about what was witnessed. Only when there was a consensus of what they had seen could the matter of fact be established. To achieve this what was needed was a public space with several witnesses.

Key to the act of witnessing is what Boyle called the “modest witness.” The modesty, what did it entail or mean? It meant that the witnesses had to be reliable people who would not let their personal preferences, personal desires, personal biases influence what they saw, and what they would say they saw. That is what excluded women because the belief at the time was that the modesty of a woman was of the body, that she did not have modesty of the mind.

The third technology is a literary technology. It was for those who could not be there, present to witness the experiment whether they lived in some other country or simply could not come. They had to develop a technology that could describe what happened without interjecting any opinion. This literary technology came to be known as the objective style of writing. “It has happened,” that type of linguistic construction. It was so that those who were not present could have what came to be called a precise and objective account of what happened. The remaining technologies had to do with the distribution of these texts. So those are the three technologies.

5.3.6 Third cut - The enclosure, the double-sided ledger, the laboratory and the multicultural science education debate.

A notion that persistently resonates as the multicultural science education debate is diffracted with this segmented cut of Dr. Apffel-Marglin’s interview is that, as Aikenhead (2006a) reminds us, “natural philosophy [is] the handmaiden of technology” (p. 11). Scientific technologies are never simply the applied form of science knowledge: they always come to co-constitute one another. As Harding (2008) states, technologies are never simply neutral nor passive cultural surfaces, as they are both the products and producers of cultural values.

\(^{108}\) Considering science and science education as entangled with/in legal-juridical modes provides insight into the ongoing practice of dialectic rather than dialogue, as explored within Chapter 2, as scientific subjects are required to dismantle their opposition’s arguments before a “court” of their peers (e.g., peer review).
Expanding upon the lines of thinking followed within the second cut, not only is the operationalization of Cartesianism an enactment that is distributed amongst a series of agents, but it is also distributed amongst a series of increasingly “common” technologies which precede, live alongside, and succeed Boyle, Netwon, and Descartes. If we think diffractively about technologies (and not only scientific ones concerned with generating or applying knowledge about nature) then: Nature, metaphysics, as well as how they are understood and enacted through knowledge-practices always come to bear. Social, political, and economic technologies come to be ontological enactments; as well as epistemic ones in which social, political, and economic dimensions come to coalesce without ever fully achieving sameness (see Barad, 2007; Kirby, 2011). The technologies of the enclosure, the double-sided ledger, as well as the laboratory are all supported by particular ways-of-knowing-nature such that they are produced by and (re)produce a “metaphysics of individualism” (Barad, 2007): knowing-in-being premised upon matter and meaning being separable and individuated through mutual exclusivity. Such ontological cuts are never neutral, but are always already entangled with culture and ethics; even if the enactment is (re)producing epistemic, ontological, and ethical separation, it is nonetheless placed within a set of relations, even if the relationships go unaccounted for and unaccountable within said framework.

This includes, of particular significance to the multicultural science education debate, the very practices of the laboratory. The practices of knowing nature within WMS are often premised upon scientists operating from a culturally unbiased, neutral, and detached position (see Aikenhead & Michell, 2011; Aikenhead & Ogawa, 2007; Siegel, 2001), and are supported by social and literary technologies which assist in the production of such (e.g., the laboratory as public space, objective writing style, and modest witness). However, as Dr. Frédérique Apffel-Marglin states, “the scientific method had everything to do with politics, economics, and religions of the time and place.” As mentioned herein, Thomas Boyle, a key figure in the development of the laboratory as a technology, was also a landowner. In turn, his politics outside the laboratory came to shape his politics inside the laboratory even if the laboratory were to be promoted as an apolitical space; he would implicitly and explicitly be bringing in and enacting the technologies of the double-sided ledger and the enclosure

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109 Recall that, as explored within Chapter 2, the laboratory is the real or imaginary context in which scientific knowledge-practices are produced and enacted. As van Eijck and Roth (2007) suggest, the generation of scientific knowledge requires that the context under observation be transcended and treated as if it were static, singular, and homogenous. In turn, scientific knowledge praxis requires that the context of its application also be treated as such. When considered as a practice which is also translated into science education, it is important to consider the (re)production of the double(d) subject of the laboratory: both Nature as subject of inquiry and scientist (or student-thinking-like-a-scientist) as inquiring subject.
within the laboratory whether they could be or were accounted for. Note that one should not confuse the practices of the laboratory with those of the enclosure or the double-sided ledger, but rather, thinking diffractively (or even with prismatic dispersal) speaks to the ways in which these practices intra-act with one another in non-negligible and dialogical manners: creating something that is not dialectically mirroring one or the other through sameness but creating a complex hybrid practice whose historical and agential constitution often goes unaccounted for.

Recall that, as mentioned earlier within the chapter, attempting to make sense of and act with TEK and/or IWLN through a Eurocentric-Cartesian framework almost always results in the perception of these knowledge-practices as lesser alternatives to WMS. Thinking with Frédérique here expands upon that notion: a Eurocentric-Cartesianism framework does not only come to devalue other ways-of-knowing-nature. When considering its operationalization as well as its entangled practices, it also comes to disrupt their (re)generation. Dr. Apffel-Marglin makes the case above that the entangled practices of the enclosure and the double-sided ledger come to produce destabilizing patterns within TEK systems within Western Europe at the turn of modernity, patterns which would and do continue through the imperial cum capitalist project of (neo-)colonialism.110

First, through the practice of the double-sided ledger, land can be assessed as through a reductionistic logics of equivalence and sameness through quantifiability. In the short physical space between one side of the ledger and the other, the human, other-than-human, and more-than-human ecology of relationships is reduced to both a spatial area and a fiscal value which are given the status of equivalency: a veritable trick of smoke and mirrors. Secondly, by making the commons private through the enclosure, the unaccounted for relationships which shape entire lived knowledge systems are disrupted. Knowledge holders no longer have the same type of access to the landscapes with and from which they learn (see Cajete, 1994); furthermore, the relational and ethical knowledge-practices through which these ecologies are (re)generated are not sustained. Lastly, when the enclosure and the double-sided ledger are metaphorically inflected through human bodies that live(d) in and with the commons, they too become commodities. The biological boundedness of the human body and the economic logics of sameness (re)shape labour as commodity rather than

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110Apffel Marglin (2011) states that if colonization was so effective, it was because it was perfected through its internal application within Western Europe before it was exported to Western Europe’s Others. Along similar notes, during her talk titled Four Theses on Posthuman Feminism at UBC, Rosi Braidotti stated that the Holocaust was “colonialism coming home” (January 28th, 2015). The point to be made here is that (neo-)colonial systems come to affect us all, even if they do not affect us all in the same way (see Battiste, 2005, 2013b; Donald, 2011; Freire, 1970/200): they differentially inflect our respective (re)production as de/colonizing subjects.
something that one gives and receives unequally but rather equitably within a reciprocal gift-based economy: “You own your body; and because you own your body, you can sell your labour power on the market.” As these values came to permeate the social, political, and economic facets of Western modern life, it “profoundly transformed the sense of what a person is and can be” by (re)shaping the norms of subjectification.

While these social, cultural, political, and economic values slip their way into scientific practice unnoticed and unnoticeably due to its framings as *apolitical*, the *apolitical stance* of the modest witness is also produced by the social, cultural, and political climate of the time, as explored within the next section.

**5.3.7 Fourth cut – Dr. Frédérique Apffel-Marglin on the modest witness, when One Truth becomes two, and the Thirty Years’ War.**

M.HIGGINS: Regarding the modest witness and the norms that shape who can be a witness, you’ve mentioned that women were excluded on the basis of the gendered understandings of modesty at the time. Were there other people who were excluded and on what basis?

F. APFFEL-MARGLIN: Yes, there are absolutely others. In the laboratory’s beginning, to be in the lab, you had to be independently wealthy to participate. This was for two reasons. First, you had to be wealthy because it was personally expensive: you had to have the time, as well as have education that entailed knowing mathematics and a few other things. Only the wealthy people could be educated; they were all men. As such, the “modest witness” excludes not only all women but also a lot of men such as the lower classes and the uneducated ones.

Secondly, it was systematically expensive. This was because the university was church business. One of the fundamental characteristics of the lab, as Boyle set it up, was that within that space it was absolutely forbidden to talk about religion and politics. Now why do you think that was? Why do you think he made that rule if we’re talking about the 17th century and what was going on in the 17th century?

M.HIGGINS: There were still witch-hunts going on, right? There would be politico-religious consequences for those who might be hylozoists and hermeticists, which go far beyond attempting to be “modest” in one’s assumptions and biases, correct?
F. APFFEL-MARGLIN: Yes, and what else?

M. HIGGINS: There also would have been the politics of land ownership I gather, but I’m guessing that there is something even more critical than this.

F. APFFEL-MARGLIN: Wars of religion. They are also key in understanding the birth and operationalization of the Boyle-Newtonian-Cartesian framework. It started with the Reformation in 1510 with Martin Luther. Protestants immediately had a following amongst the merchant and certain aristocratic classes, and even among some royal families. It divided countries between regions that were Protestant and regions that were Catholic.

The Catholic Church is a centralized church which has a pyramidal hierarchy with the Pope at the top. Because of its pyramidal and international organization, as well as its domination of education at all levels, they could decide what people should and could think and read, as well as what they should not think or read. It still exists today, the means through which a dominant curriculum was established and monopolized: what they call Librorum Prohibitum. It tells you what is what, what is true, what is superstitious, and what is false. They also have the power of excommunication, which was very powerful at the time. It is not like today.

The problem then and there was the following. The reformation spread very quickly. Protestants stated “we have the truth; the Catholics are mistaken; what they do is magic.” In Western Europe, the One Truth became two. Both Catholics and Protestants each said they had the One Truth. It was explosive. Indeed, it created mayhem. They killed each other with gusto, brutality, and horror.

In the early 17th century, they assassinated Henri IV, King of France [not to be confused with Henry IV, king of England from 1399 to 1413]. He was Protestant but to be king he had to be Catholic. That is what he meant by his famous line: “la France vaut bien une messe.” It was well worth going to mass in order to be the king of France. There were 8 bloody civil wars in the 16th century, in the 1500’s, so he made a very famous law: the Édit de Nantes in 1598 [the Edict of Nantes]. It was a very modest proposal to live together without killing each other. In regions in which the majority was Protestant, the Catholic had the right to have their religion albeit not display it publicly. In regions in which the majority was Catholic, it was the reverse. They had the right to practice, but not to display; not rub it in the face of the other. While it was a minimalistic
accommodation, it worked. However, there were 10 assassination attempts against Henry IV, and finally the last one worked: he was killed in 1610. His second successor, not the next king but the king after that, Louis XIV eventually threw all the Protestants, known as ‘huguenots’, out of France.

This is a thumbnail outline of something that is, in my opinion, fundamental to understanding the birth of modernity in the West. This is in relation to how it related to Christianity, and the One Truth; as well as its shift to having, all of a sudden, two One Truths. But there can’t be two One Truths, right?

What Boyle did with the laboratory, why it worked, and why it became the prevalent approach in that day and age by accruing the most political and economic power, was because it solved something that was unsolvable. This unsolvable issue was the One Truth becoming two truths with each religious organization saying: “we have the One Truth and you are heretics.” When echoed, this led to killing each other. When Boyle created the lab and stated that you could not talk about religion within that space, he created the germ or seed of secularization. The lab, and with it all of Nature, became a neutral domain outside of religio-political domains, a new neutral domain upon which the lost certainty to which Europe was addicted could be safely reconstructed.

The lab was the first neutral, or in other words, secular place in Europe. Before that, you could not be a secular person; it did not exist in Western Europe or anywhere else. That is the birth of religion as a category. Before this, spirituality was interwoven into the fabric of life: it was one seamless way of life. That is the way it was. So this was the first time that you had a space where you could not talk about what pervades life or has pervaded life for everyone.

Speaking of religion was simply forbidden. And why was it forbidden? It was very simple: if you talked about religion, you might kill each other. The reason why politics could not be discussed within the laboratory is because politics and religion went hand in hand. They could not be separated. The Protestant had their political leaders and the Catholics had the king. Politics and religion were one and the same.

What Boyle was creating was a separation for a very pragmatic reason. He was creating a space where you could argue in a friendly, non-conflicting, and accordingly non-lethal way about other matters. What are the other matters? What you have witnessed within the laboratory. Because the model is the court, there is one more reason why he used the judiciary model of argument. Within the laboratory, everyone had a right to participate if you did not touch upon topics of politics
and/or religion. Because they had a right to opine, the consensus that emerged around what happened through experimentation would be strong.

At the time, his greatest competitor, Thomas Hobbes was arguing for a new model in which people would not disagree. This was seen as dogmatic. Boyle was trying to get away from the dogmatism of the Catholic Church and the Protestants. He was attempting to get away from the idea that people have no choice because of dogmatic statements “this is how it is” whether Protestant or Catholic. He was moving away from that while strengthening truth claims through encouraging disagreement within very strict boundaries. When you allow people to disagree within bounds, the consensus is strong without being dogmatic. It became a very powerful solution that addressed and solved the issues of the times within the privileged space of the laboratory.

M. HIGGINS: If I understand this correctly, this would also have consequences for what was intended by modesty at the time. As you speak to in your book Subversive Spiritualities, secular modesty put forward by Boyle in the laboratory is very different than the religious modesty put forth by the Christian church before it. Religious modesty entailed not being a spiritual usurper, not having too many belongings in this world, or to be a martyr of sorts. Secular modesty, in contrast, largely meant being “modest” in one’s beliefs by abstaining from talking about religion or politics. However, if the secular modest person also had to be wealthy as an entry point to participation, this circumvents ethical questionings of wealth altogether.

F. APFFEL-MARGLIN: You simply did not discuss those things in the lab.

M. HIGGINS: The process of supersessionism, or the ways in which WMS supersedes Indigenous and other ways-of-knowing-Nature, could be said to have an almost religious quality to it. However, this is not because of ties to the church, but as you identify, this largely has to do with what you identify as an addiction to certainty and objectivity/subjectivity as one of the ways in which the Nature/Culture binary plays out. Could you elaborate upon this process?

F. APFFEL-MARGLIN: As I mentioned earlier, the social-political-religious landscape of Western Europe in the 17th century was one of raging religious wars and the Burning Times which came to an end in the second half of the 17th century. As I like to say, irreverently, Europe was addicted to the
One Truth because it had lived with it for 15 centuries or more with Christianity. Europe required certainty to restore law and order, as Stephen Toulmin has shown in his book Cosmopolis. A new neutral – and very separate – domain of inquiry, Nature, and with it a new epistemology, were required. That new epistemology needed to have its life in a new neutral space, that of the laboratory. While there are exceptions, this is still true today. The One Truth is an addiction.

So in order to resolve the impossibility of two One Truths in Europe, a circumscribed space that was neutral vis-à-vis both the Protestants and the Catholics was invented. Within this space, a certainty that was not religious was created. It was desperately needed and it was a very circumscribed space. Hence, the laboratory took off.

At the time, religious wars were international. The Thirty Years’ War, which lasted from 1618-1648, was the internationalization of what I described in France earlier. Similar things were also happening in England and Germany. The Treaty of Westfalia was signed to bring an end to the Thirty Years’ War. This process creates, invents, and necessitates the nation-state.

Immediately, the nation state needed a science to function and to govern. Here, I draw from the work of James Scott and his book Thinking like a State addressing why the nation state cannot function without science. I cannot simplify that story for you, but I will attempt to give a quick and partial view. In a nutshell, the state has to manage two things. First, it has to manage conflict, which was religion-based. Secondly, the state had to generate revenue. To get revenue, you have to systematize and quantify. It is like what the encloser would do when calculating his advantage but now this logic is playing out at the national level. This, of course, is a partial view.

M. HIGGINS: This addiction to certainty certainly has persisted strongly within Western modern(ist) traditions – to which it has had its own internal challenges (e.g., the crisis of representation in the 1990’s). However, it is not uniquely internal to Western traditions as the addiction to certainty is being exported and culturally transposed…

F. APFFEL-MARGLIN: Through the hegemony of modern education worldwide!

M. HIGGINS: In your book Subversive Spiritualities, you speak to the addiction to certainty and how WMS (i.e., agricultural models in particular) supersedes Indigenous local, longstanding, and
intergenerational models due to the ways in which it is framed or enacted as holding a high degree of certainty. Could you speak to the ways in which certainty was and continues to be constructed?

F. APFFEL-MARGLIN: Here is the way I’ve come to see it. The founding myth of Modern science is the trial of Galileo vs. the Catholic Church. Here you have rationality and belief. Of course, this myth was carried forward into and leads to the progressive secularization of society through the laboratory later through the Nation State. This created certainty on a whole new basis: the experimental method, deduction, rationality, logical thinking, objective writing, and all; the whole package.

What I see when I take that long view is that religious certainty has been transposed into a new key, to use a musical metaphor. Scientific certainty is the same thing but, of course, the new key is crucially different. The key is crucially different but the tune is the same. It is similar in its absoluteness in the sense that its method is the only valid one, its claim to the One Truth: Science gives you the One Truth but in a new language and on a new basis. In the process it had to disenchant nature, as Weber put it, and with that move transmute all other ways of knowing-being as “pre-scientific” in need of progress. Because Western Europe was addicted to certainty and the One Truth, it had recreated it in a new secular key with Modern science.

That is why the “universal” given-ness of Nature is so pernicious. Scientific rational superiority became a deliberate part of an educational campaign to inculcate in the European youth, and to shape perceptions about those who Europe colonized. Colonialism is justified through statements such as “this is right because we are enlightening these unenlightened people; we are bringing them not just civilization, we are bringing them knowledge, True knowledge.” Of course, such is predicated on seeing Nature as universal.

As Karen Barad says, you can never separate or disentangle the discursive from the material. This disentanglement, however, is key to the formulation of certainty. The issue for me is that it is very difficult to have people understand this because it goes against the grain of everything they likely have been taught.

M. HIGGINS: Dualistic thought is not something that can simply be turned on or off.
F. APFFEL-MARGLIN: Exactly. You can say it conceptually in all its implications. However, what happens in practice is otherwise and extremely difficult.

M. HIGGINS: Which dualisms are we reproducing as we try to work against others?

F. APFFEL-MARGLIN: It is always a process; an unfinished work.

5.3.8 Fourth cut – The modest witness, when One Truth becomes two, the Thirty Years’ War, and the multicultural science education debate.

Reading the insights provided by Dr. Apffel-Marglin in this vignette through those of the multicultural science education debate begins to reveal the ways in which the apolitical stance of cultural quasi-neutrality explored within chapter is a process which comes to mask the flow of common-place cultural power and politics into the laboratory, but also the ways in which this stance is produced by the social, economic, and political forces of the time. What might appear as an individualistic choice here could be (re)thought as having and being had by common sense.

This stance, as Frédérique enunciates it, is one of being a modest witness. The modest witness, as one of the multiple technologies that come to constitute laboratory practice requires that the individual whom is witnessing be educated, as well as “modest of mind.” Here, we come to see the Foucaultian circularity of knowledge comes to rear its head again. First, recall that the Nature/Culture exclusive dichotomy, with/in which WMS is entangled, comes to negatively position Man’s (human) Other as “closer to nature.” Accordingly, women, racialized bodies, Indigenous peoples, amongst others, as being perceived as possessing “modesty of the body” rather than that of the mind, were generally not included in the very processes which would implicitly (and eventually explicitly) come to position them as having lesser ability to bear witness to natural phenomena. Secondly, as Dr. Apffel-Marglin states, one must also be educated to participate. As this required access to wealth, those of lower class would also be excluded (see also Haraway, 1997; Shapin & Schaffer, 1985). While one could say that that was then and this is now, it is nonetheless important to consider how science and science education’s historicity continues to shape them as

111 In turn, it is productive to address the ways in which the mind/body binary come to operate within science education when working within and against Cartesianism. For example, recall that in Chapter 2 you were encouraged, as a reader, to also pay attention to the affective ways (e.g., emotive, sensory) in which information registered upon their body. If science is to be framed as a human practice (see Aikenhead, 2006a), it is worthwhile and important to consider, account for, and be accountable to the plural and diverse ways in which we are human.
they move forward. While science education is increasingly perceived as being enacted as a practice for all students (see Aikenhead & Elliot, 2010), it is nonetheless important to continue considering how the all in such statements are articulated, especially when science education scholars continue referring to WMS as white male science (Pomeroy, 1994; see also McKinley, 2000; Sammel, 2009).

Accordingly, while the practices of who gets to do science have explicitly changed, many of the implicit meanings remain when we consider the ways in which the how of science were and continue to be framed. As Frédérique makes explicit, the practice of being a modest witness cannot be separated from the socio-political context of the time in Western Europe: particularly from what was happening within the sphere of the Church. Following the establishment of the Protestant Church, Western Europe was thrown in turmoil: a powerful addiction to certainty and competing claims of holding the One Truth would see Catholics and Protestants kill each other “with gusto, brutality, and horror” for a thirty year period. Following the Thirty Years’ War, there was need of a system of governance that would not bound to either religion: in the creation of the scientific laboratory, we would also see the birth of secularism. As Dr. Apffel-Marglin puts it, this came to shape the very practice of the laboratory in its infancy in profound ways: “it was very simple: if you talked about religion, you might kill each other.” However, as mentioned earlier within this chapter, the creation of secularity as mutually exclusive from spirituality had consequences then and now: practices, like TEK and IWLN, that do not see separate spirit and matter are implicitly (and sometimes explicitly) not welcome within the formal spaces of science. This trend, while far less explicit continues to bear on educational spaces today: recall that in Chapter 2, there continue to be many science education scholars, as well as science educators who frame practices other than WMS as less valid (e.g., Cobern & Loving, 2008; Siegel, 2001).

In these instances, it can be said that there continue to be traces of what Frédérique refers to as the One Truth: “religious certainty has been transposed into a new key, to use a musical metaphor.” The aforementioned claims of validity do not come to frame WMS as being more valid in particular moments within the multicultural science education debate, but rather as a general and a “universal” which is a priori to knowing and being. It could be stated that the transposition of power

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112 While not directly discussing spaces of science education, Marker’s (2006) After the Makah Whale Hunt is a rich exemplar of the complexities and complications which arise when bringing in Indigenous knowledges and knowledge holders into schools to discuss other-than-human members of a local ecology. As school spaces are secular (through separation of Church and State), but seen as neutral and the norm, the inclusion of IWLN and its interconnectedness of spirit and matter is brought into sharp relief and becomes a site in which Eurocentrism plays out in diverse manners (e.g., excluding knowledge and knowledge holders, only including such lesson if it omits its co-constitutive spiritual dimension).
from the Church to the laboratory as instrument of the State did not address or redress Western Europe’s addiction for certainty at the time, but rather resituated and differentially produced the ways in which one had access to the One Truth. It is for this reason that Spivak (1976) cautions against the (too) rapid evacuation of a concept, category, or framework: left unaddressed, its problematics often follow us in ghastly and ghostly manners to reassert themselves elsewhere albeit differently. The calling into question of the claim of “most valid” is not to deny it, but rather resituate it by asking the questions of when and where it is most productive; few science education scholars deny the pragmatic effectiveness of WMS in making knowledge claims about nature. However, science is indebted to and weighed down by the ways in which the One Truth continue to (re)shape it: science education continues to be a space which dialectically subsumes and sutures over TEK and IWLN as a means of resolving difference and reasserting WMS as a more nuanced version of the One Truth in an ever diversifying world.

5.4 Conclusion: Positing, Accounting for and Being Accountable to an Ontology in Science Education

To address the past (and future)... is not to entertain or reconstruct some narrative of the way it was, to respond, to be responsible, to take responsibility for that which we inherit (from the past and the future), for the entangled relationalities of inheritance that ‘we’ are, to acknowledge and be responsive to the noncontemporaneity of the present, to put oneself at risk, to risk oneself (which is never one or self), to open oneself up to indeterminacy in moving towards what is to-come. Responsibility is by necessity an asymmetrical relation/doing, an enactment, a matter of différance, of intra-action, in which no one/ no thing is given in advance or ever remains the same. Only in this ongoing responsibility to the entangled other, without dismissal (without ‘enough already!’), is there the possibility of justice-to-come. (Barad, 2010, pp. 264-265, emphasis in original)

Within the context of multicultural science education, the relationship between science (i.e., knowing nature) and justice (i.e., respecting diverse cultural knowledges) often continues to be dichotomized. This make it such that the debate between the pre-dominant universalist and cross-culturalist positions rarely produces productive intermediary positions from which to take up both of these competing claims in the ways in which they are articulated. While there is a responsibility to be accountable to both, the ability to respond is foreclosed. Without being able to account for and be accountable to the “the entangled relationalities of inheritance that ‘we’ are” (Barad, 2010, p. 264): Cartesianism and the Nature/Culture cuts that it enacts goes unnoticed, unheeded, unchecked. Such an inheritance is non-contemporaneously entangled within the production of science education and educators. In other words, it is not only to give an account of a past modernity which is never quite past, but also an accountability towards the ways in which this past continues to shape science education and educators. This entails, as Latour (2004b) states, accounting for the ways the
Nature/Culture binary makes science and cultural politics incommensurable. In turn, responsibility and the ability to respond both require “an iterative (re)opening up to, an enabling of responsiveness” (Barad, 2010, p. 265) towards other-than-Cartesian possibilities. Thankfully, as Latour (1993) reminds, the Nature/Culture binary is never fully achieved or achievable. “We Have Never Been Modern,” as the eponymous title of Latour’s (1993) book proclaims, there is always already the possibility for knowing-in-being otherwise.

I conclude with further questions about the space of ethical response-ability towards Indigenous science to-come offered by positing an ontology: if how we think (e.g., Nature/Culture binary) is the very thing preventing forward momentum with/in the multicultural science education, how do we think about how we think without using the very thing with which we think (see Higgins, 2014a)? Also, what types of pedagogy might allow for students similarly engage in a (re)opening towards Indigenous science to-come (see Chapters 6 and 7)? How might science educators move towards ethical response-ability when responsibility is not something that we simply have that pre-exists our engagements but rather is also something by which we are had, that is produced in its complex flow through and by us? How can we be accountable to how we are always already (re)produced by science education as educators? Similarly, how can we foster response-ability to what we produce within the ever-changing field of possible possibilities science education (as part of the world’s ongoing becoming)? Lastly, what types of theory-practices might facilitate the im/possible but necessary accounting for what our onto-epistemological enactments produce within science education?

The very ability to respond to the to-come is, as Barad (2010) reminds, an “ongoing responsibility to the entangled other, without dismissal (without ‘enough already!’)” (pp. 264-265). Responding to Indigenous science to-come not achieved “through the realization of some existing possibility, but through the iterative reworking of im/possibility” (p. 265). While there is no singular solution to such questions, positing an ontology paves pathways to engage with the im/possibility of being wholly accountable to and ethically responsive by coming-to-perceive the very possibility of ontological otherness, as well as accounting for the ways-of-knowing-in-being which foreclose such possibility. To re-iterate, situating science education ontologically by positing an ontology is not about who is right or who is wrong, nor is it about a renewed commitment to relativism. Rather, it is about coming-to-recognize a plurality of possibilities, and in turn, it means being accountable to how scientific knowledge is produced, produce-able, and what it produces in turn within and beyond the
science education classroom. For example, thinking with Frédérique Apffel-Marglin allowed me to differentially consider the conceptual baggage that comes with the metaphysics of modernity, not to dismiss or do-away with these ways-of-knowing-in-being but rather come to work with/in the structures that (re)produce and are reproduced by science education in order to (re)open them to Indigenous science to-come. These include the “uncommon” political, religious, economic, and military practices (e.g., the enclosure) that are enfolded and co-constituting “common” scientific technologies and practices (e.g., modest witness) of a non-dissociable past and present.

Because “how reality is understood matters” (Barad, 2007, p. 205), the (re)working of lines of inclusion/exclusion that such understandings and enactments produce are always already becoming something else. This (re)working towards positing an ontology is an ethical call which we must all heed with/in our distinct yet never (fully) disentangled situatedness if we are to heed Indigenous science to-come.
Part 3: De/signing and Delivering a Curriculum for Indigenous Science To-Come
Chapter 6: Responsibility, Response-ability, and Science Education: Towards Re(con)figuring Science Curriculum and Pedagogy

Native and Western cultures, with their seemingly irreconcilably different ways of knowing and relating to the natural world, must search for common ground and a basis for dialogue. (Cajete 2006, p. 248)

All the basic components of scientific thought and application are metaphorically represented in most Native stories of creation and origin. Indeed, both Native science and modern science have elements of the primal human story in common. They have, however, evolved very different orientations to the natural world and very different expressions of thought regarding the role of humankind in coming to know our place and our responsibility to the creative unfolding of the greater story of the universe. As we enter the first decade of a new millennium, Native and Western cultures and their seemingly irreconcilably different ways of knowing and relating to the natural world are finding common ground and a basis for dialogue. (Cajete, 2000, pp. 13-14)

In Chapter 2, one of the ways in which scientific knowledge was (re)considered as a knowledge-practice (among many) was to extend science’s internal dynamism and heterogeneity outwards by considering the complex and conflicting ways in which WMS, IWLN, and TEK interact and interface. As a knowledge-practice, this interface is not a location that simply *is* but rather is a *doing*. It is an enactment that is often marked by the assumption that cultural traits are separate and separable (van Eijck and Roth, 2009; Higgins, 2014a; see also Nakata, 2007a, 2007b). This renders invisible: a) the many elements of WMS that stem from non-Western cultural sciences and vice-versa and their historical; b) the complex co-constitutive and cross-cultural scientific knowledge production processes; c) the complexities that occur at the currently lived and differently situated cultural interfaces that both they and their students occupy (see Belczewski, 2009; van Eijck & Roth, 2009; Higgins, 2014a; Snively & Corsiglia, 2000).

Cajete (2000, 2006) states that there is at once a need and a possibility for dialogue across Indigenous and Western “ways of knowing and relating to the natural world” (2006, p. 248) despite their “very different orientations to the natural world” (2000, p 13). However, the relationship between Indigenous and Western knowledge systems is often referred to as one of “Jagged Worldviews Colliding” (Little Bear, 2000). It is a relationship that has often been describes at best as tenuous, and at worst as “seemingly irreconcilably different” (Cajete, 2000).

In turn, within this chapter, I engage with the possibility of placing TEK, IWLN, and WMS in dialogical relation *in* and *as* science education. In response to the complexities of the space between Indigenous and Western ways-of-knowing-nature, the following questions guide ethical examination and design: *How might science education account for and be accountable to these uneven and unequal relations of power? What kind of curriculum and pedagogy might open a space*
of response-ability in science education towards Indigenous science to-come? “What kind of [curriculum and] pedagogy would help students to learn about practicing responsible science?” (Barad, 2000, p. 239, emphasis mine). Also, a Cartesian ontology is rife with onto-epistemic enactments that threaten to (fore)close the ability to respond towards a space of dialogue between TEK, IWLN, and WMS (see Chapters 2, 4, and 5). As the space of/for responsibility is always already at risk, What kind of science education might consistently rework itself to be accountable for and towards its co-constitutive exclusions (see Barad, 2000)?

Asking questions of ethics before-the-fact (i.e., what would be or might be responsible) rather than after (i.e., what is or has been responsible) is in alignment with being accountable to the agential cuts that enact (see Chapter 5) and attempts to heed Barad’s (2012a) cautionary note that the “notion of consequences is [often] based on the wrong temporality: asking after potential consequences is too little, too late” (Barad, 2012a, p. 53). To uphold these commitments ethical questions focus on pedagogical design, rather than delivery.113

The task of placing TEK, IWLN, and WMS in dialogical relation in and as science education is engaged with and through a methodological-pedagogical design as a double(d) moment of suspended action (Bohm, 1996; see Chapter 2). Recall, suspended action is a lived practice of dialogue and a (partial) coming-to-awareness of what we think, as well as how what we think is produced and produceable. The latter entails considering how values are inflected, deferred, and deflected through our selves. This double(d) mo(ve)ment, which bears resemblance to Apffel-Marglin’s (2011) “reverse anthropology” (see Chapter 5), might allow us to rethink and displace the self-in-relation to the norms that shape how, who, and what we can be and do with explicit attention to the ways-of-knowing-in-being which produce Indigenous science as to-come. Thus, I draw on what I’ve learned about how WMS is co-constituted by Eurocentrism and Cartesianim through the pathways tactically wandered with/in this dissertation. In particular, I draw on insights regarding and re(con)figuring some of the following: adversary method and dialectic (Chapter 2), critique as mirroring and its associated metaphysics of individualism (Chapters 3 and 4), and the practices entangled with/in WMS (e.g., modest witness, enclosure, double-sided ledger; Chapter 5). My partial

113 Nonetheless, delivery was a component of the larger research project and glances at what delivery produced are provided in the next chapter.

Furthermore, as explored in Chapter 5, “design” (i.e., research design) is a notion that is often overcoded by a theory/practice binary (which is co-constituted with/by a Nature/Culture binary) in which design often pre-exists practice, rather than always already being entangled within its production. In turn, this chapter is not about translating “theory into practice” (which presupposes separation and separability) but rather translating the theory-practice of earlier chapters into a differentially contextualized theory-practice (see Higgins et al., in press).
and contingent knowledge\textsuperscript{114} of Indigenous science also supports the (re)opening of science education for Indigenous science to-come. Such an attempt recognizes that Indigenous science and WMS are not simply different natural-cultural articulations, but also within unevenly distributed relations of power.

This chapter is divided into five sections. First, I begin with a primer on what Martin Nakata (2007a, 2007b) refers to as the “cultural interface” between Indigenous and Western ways-of-knowing-in-being as a means of conceptualizing the unevenly distributed relations of power at the interface. This section also considers the interface as a cross-cultural location for/as methodological-pedagogical design. Second, as positionality is established with/in other chapters, I discuss my relation to the chapter’s exploration through a storied vignette. Within and from this vignette, I begin an exploration of the concept and practice of response-ability in decolonizing science education. I consider, if science education is a space that dialectically negates Indigenous science to-come, how might the ability to respond be (re)opened to take up the responsibilities that science educators always already have? Third, as this chapter (formally) marks the shift from deconstruction to reconstruction, the co-constitutive approaches to decolonizing education within this dissertation, I elaborate upon response-ability as a methodological deconstructive-reconstructive concept with which to think and design \textit{a} (i.e., singular) reconstruction of science education. Fourth, thinking with response-ability to heed the call of Indigenous science to-come as a responsibility of science education, I engage in a critical and complicit re(con)figuration of science education curriculum around the central and significant node of scientific literacy. Fifth, I similarly engage in a re(con)figuration of photovoice as a pedagogical tool for exploring a re(con)figured scientific literacy.

\section*{6.1 A Preamble on Considering Methodology for/at the Cultural Interface}

As Leroy Little Bear (2016) signalled in his talk, \textit{Blackfoot Metaphysics is Waiting in the Wings}, there is no metaphysics that exists outside of its relationship to others. However, the troubled and troubling relationship between Indigenous and Western ways-of-knowing-in-being is prevalently and problematically attributed to a decontextualized and ahistorical account of difference within many spaces, where dichotomous differences are conceived and Indigeneity is presented as deficient other-ness (Donald, 2011; see also, Spivak, 1988a, 1999). However, as Dei (2000) reminds

\footnote{\textsuperscript{114}Partial knowledge does not reduce or dismiss responsibility: all knowings are partial and contingent. Furthermore, partial knowings are nonetheless knowings (see Butler, 2005).}
us, “Indigenous knowledges do not ‘sit in pristine fashion’ outside of the effects of other knowledges” (p. 111). Furthermore, Western knowledges are also not “immune” to the influence of Indigenous and other knowledge systems (Harding, 2008; Little Bear, 2000, 2016). Even if it were organized as a dichotomy, it is porous and always already deconstructing in an ongoing cross-cultural becoming.

Accordingly, for spaces that are always already at the cultural interface like Indigenous knowledge systems and practices in the academy, there is perhaps a need for a “different conceptualisation of the cross-cultural space, not as a clash of opposites and differences but as a layered and very complex entanglement of concepts, theories and sets of meanings of a knowledge system” (Nakata, 2006, p. 272). While there are increasingly points of resonance within this in-between space (Davis, 2008; Peat, 2002), one should not be overly or only romantic about the possibilities (Carter, 2004, 2010). Furthermore, just as one should not be imperceptive to the ways in which these potentially productive hybrid spaces remain contested and complicated, it is also problematic to (too easily) write them off altogether (Donald, 2011; Kuokkanen, 2007; see also Spivak, 1993/2009, 1994). In other words, there continues to be a need to remain critical and complicit towards these possibilities. I agree with Nakata (2007b) who states, “not opening up theoretical positions for more complicated discussion means that the cultural interface is sutured over in favour of the Western order of things and its constitution of what an Indigenous [and ally] opposition should be” (p. 10-11), and, I would add, possibilities beyond opposition such as dialogue.

The cultural interface according to Nakata (2007a, 2007b) are particular discursive nodes where competing and contesting knowledge systems are positioned alongside and against each other in ways that are shaped by various discursive practices (e.g., theories, epistemic regulation, social imaginaries) that dynamically intersect with the materiality of place, space, and time. As Nakata (2007a) states, these nodes:

inform, constrain or enable what can be seen or not seen, what can be brought to the surface or sutured over, what can be said or not said, heard or not heard, understood or misunderstood, what knowledge can be accepted, rejected, legitimized or marginalized, or what actions can be taken or not taken on both individual and collective levels. (p. 199)

Not unlike Butler’s (e.g., 1993, 2005, 2010) theorization of performativity, Nakata invites us to consider that the cultural interface is not a totalized or deterministic space in which agency is foreclosed. Moreover, as introduced in Chapter 2, the interface is something you do (as knowledge-practice) rather than something that is (as knowledge). Agency is framed by the possibilities and
limitations of the cultural interface. In particular, considering agency at the cultural interface invites us to consider how the plurality of coalescing and competing forces and flows produce “the very conditions to what is possible between Indigenous and non-Indigenous positions” (Nakata, 2007b, p. 13) in their dis/continuity and uneven relationality. Negotiating these spaces is not a question of who can know or do, but rather what can be known and done through negotiating, navigating, and exploring this lived everyday tension while recognizing that:

People’s lived experience at the interface is the point of entry for investigation, not the case under investigation. It is to find a way to explore the actualities of the everyday and discover how to express them conceptually from within that experience, rather than depend on or deploy predetermined concepts and categories for explaining experience. (Nakata, 2007b, p. 10, emphasis mine)

Elsewhere, drawing from personal lived experience as a point of departure, I have argued with respect to decolonizing pedagogies (Higgins, 2014a) that every attempt to work against colonization is also within colonization and inevitably reifies (neo)colonial constructs, concepts, or structures through the process. In turn, the cultural interface provides a rich conceptual location to consider decolonizing pedagogies as de/colonizing to explore the (neo)colonial complexities and complications that emerge through the practice of decolonizing pedagogies (Higgins, 2014a; see also Carter, 2004, 2010). In its earlier iterations, it has been argued that the cultural interface is an incredibly productive and apt concept for situating Indigenous learners within teaching methodologies (Nakata, 2007a, 2007b), as well as non-Indigenous learners engaging with Indigeneity (McGloin, 2009). Lastly, I have also argued elsewhere (Higgins, 2014b), that this co-substantive location is also a productive site from which to consider de/colonizing research methodologies.\footnote{Specifically, I argue that the cultural interface is a useful metaphor for considering similarly situated research methodologies because the suturing over at the cultural interface does not occur only occur on any particular (human) body but also occurs upon many bodies of knowledge. As these include bodies of methodological knowledge, the complex and complicating ways in which this over-writing occurs need to be worked within and against.}

\subsection*{6.1.1 Methodological-pedagogical design for/at the cultural interface: (Re)considering decolonizing science education.}

This brings us back to and has bearing on what it means to engage in the methodological process of decolonizing science education. Recall that decolonizing science education entails the double(d) process of deconstructing and reconstructing. This entails at once (re)opening (neo-)colonial structures and strategies that leverage incommensurability as a means of enacting an uneven flow of power, while simultaneously (re)constructing in a way which refuses
commensurability while seeking to centre and take seriously Indigenous, diasporic, and other postcolonial ways-of-knowing-in-being in reshaping its processes and priorities. However, as mentioned in the conclusion of the last chapter, the very possibility of this type of acting upon our responsibility is directly tied to the ability to respond. This ability to respond is, in turn, tied to the past (and future-to-come) as inheritance; not as possession, but that by which we are possessed (Barad, 2010). It is for this reason, and worth recalling, that decolonizing science education must always be both a process of deconstructing and reconstructing (and not de-construction and reconstruction; see Jackson & Mazzei, 2012).

As explored within earlier chapters, there are multiple facets that shape how science education and educators are produced, produceable, and thus (un)able to respond to the necessary im/possibility of: a) enactments of adversarial dialectics that place science and ethics as binary opposites (see Chapter 2); b) the mirror metaphor that comes to mask epistemic and ontological becomings, while protecting (from) critical engagement (see Chapter 3); as well as c) the ways in which “common sense” create a circular logic that comes to simultaneously uphold and conceal an ontology of Cartesianism and its inseparable ethical and epistemological assumptions and enactments (Chapters 4 and 5). While responsibility always precedes our coming-to-knowing-in-being, the space of response-ability from which we can account for and be accountable to these responsibilities is highly productive as it invites and requires us to consider that which shapes our very ability to respond, such as some of the aforementioned knowings generated through this inquiry. Yet, the space of response-ability is ever in need of an ongoing (re)opening as the conditions which shape our ability to respond are always already on the move (Barad, 2010; Kuokkanen, 2007). Response-ability in/as decolonizing methodology is at once necessary yet never fully adequate; working against (neo-)coloniality’s shifting logics and practices entails working with purpose but without guarantee (see Spivak, 1988a, 1999).

As explored within earlier chapters, such (re)opening of science education as a location in and from which responsibility is perceptible and potentially enacted is not as simple as desiring it to be so. Rather, the cut between what science education is and is not must continue to be labored in order to allow for the possibility of what science education could become. This, as Barad (2010) reminds, comes-to-be through the ongoing process of reworking the norms of im/possibility to alter or and altering the possible possibilities (see also Kuokkanen, 2007; Spivak, 1993/2009). While aware of the necessity to and pursuing the process of (re)open/ing the space of response-ability in
science education towards Indigenous science to-come, it was not until a recent dissertation defense of a colleague that I could come to articulate its double(d) movement.

6.2 Responsibility and the Ability to Respond: How a Dissertation Defense Reminded Me of Response-Ability in/as Decolonizing Science Education

During Jeff Baker’s recent doctoral defense *Learning to Relate: An Exploration of Indigenous Science Education* on January 27th of 2016, the now Dr. Baker overviewed the role of Indigenous knowledge-practices within and as science education. Prefacing his question with how the nature of scientific language obstructs and prohibits the kinds of relations that the now Dr. Baker was arguing for, external examiner Dr. Michael Marker pointed towards the scholarship of David Bohm on the theoretical language of the *rheomode*. He then inquired, “Do you think that Indigenous languages provide a productive path for Indigenous science and science in general?”

Not knowing well part of the story regarding the rheomode (that is now with/in an other), I followed this path laid out before me in the days following the defense. As David Peat (2002) tells it:

> Our [scientific] language disposes us to employ concepts that are entirely inappropriate for the quantum world…. [David] Bohm rejected the idea of a reality composed of objects in interaction in favor of processes and activities in a continuous movement of unfolding and enfolding. Moreover, this reality is not confined to matter but extends to thoughts, feelings, and emotions unfolding within the brain and body. To Bohm there was no dichotomy between inner and outer, mental and physical, subjective and objective, for all are aspects of one underlying movement. The English language [as intended], however, keeps bringing us back to a world of objects. (p. 237)

David Bohm, in his search for a means of accounting for and being accountable to the process, flux, and relationality of quantum phenomena, recognized that these phenomena not only exceeded the enacted practice of science but also the language with which science thought about this phenomena. Language, for Bohm, is more than a representational tool that mirrored reality; it is also an enacted enfolding and an unfolding of our epistemologies and ontologies (see also Barad, 2007; Peat, 2002; Spivak, 1993/2009). Language would then come to shape what was and what was not know-able and do-able, as well as if and how it could come to be. Thus, in order to differently consider and respond to these excessive quantum phenomena, Bohm labored to envision a hypothetical language that he called the “rheomode” (see Bohm, 1980)\(^{116}\). Stemming from the greek word *rheo*, meaning *to flow*,

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\(^{116}\) Bohm’s (1980) frustrations with language center largely around the subject/object binary enacted through much of the English language and its inability to account for contexts which exceed this framing:

> The subject-verb-object structure of language, along with its world view, tends to impose itself very strongly in our speech, even in those cases in which some attention would reveal its evident inappropriateness. For example, consider the sentence “It is raining.” Where is the “It” that would, according to the sentence, be the “rainer that is
the language-to-come that is the rheomode would have been a language that dealt with processes and activity, transformation and change. This would not only be of use for the quantum phenomena he observed, but also for the interconnected work to which he brought these understandings of process and flux to, such as dialogue and creativity (see Bohm, 1994, 1996). As Peat (2002) explains, the rheomode “is based primarily on verbs and grammatical structures deriving from verbs. Such a language, Bohm argued, is perfectly adapted to a reality of enfolding and unfolding” (Peat, 2002, p. 238).

Returning to January 27th 2016, I had a post-defense meeting with Dr. Marker and wanted to return to and engage with the question of Indigenous languages, Indigenous science education, and science education in the more general sense. As our conversation converged around the possibility of bringing to bear Indigenous languages as meaningful pedagogical and curricular inclusions within science education (see Cajete, 1999; McKinley, 2007), another dialogical possibility emerged that could act as a dialogical site within, against, and beyond science education. The conversation had jogged my memory about David Bohm, the rheomode, and the space of responsibility between WMS and IWLN. As storytelling is a relational format with flexible roles (see Archibald, 2008), sometimes sharing a story entails distributed agency in which roles alternate: the story that was started by Dr. Baker was then taken up by Dr. Marker would be mine to finish. Furthermore, this fit all-too-well with what Dr. Baker had been discussing: knowing-in-being is always something that is done in relation.

doing the raining?” Clearly, it is more accurate to say: “Rain is going on.” Similarly, we customarily say, “One elementary particle acts on another,” but... each particle is only an abstraction of a relatively invariant form of movement in the whole field of the universe. So it would be more appropriate to say, “Elementary particles are ongoing movements that are mutually dependent because they merge and interpenetrate.” (p. 37)

However, not unlike Barad (2007), Bohm (1980) states that while the linguistic structures that serve us to quickly describe the macro-world are potentially better served by subject/object language than quantum phenomena, it too is exceeded:

The same sort of description holds on the larger-scale level. Thus, instead of saying, “An observer looks at an object,” we can more appropriately say, “Observation is going on, in an undivided movement involving those abstractions customarily called “the human being” and “the object he is looking at.” (p. 37)

Furthermore, one of most frequent critiques of engaging with the differential configurations of the English language that scholars such as Bohm (1980) and Barad (2007) propose and enact that I continue to encounter is one of unintelligibility. “Why do we need a new language that is so complicated?” some might ask. There is importance in the un/intelligible to push us beyond what we know, how we come to know, and in turn, what we can know. This is not only to differentially become aware of the epistemological and ontological configurations that are always already present within language, but also to (re)open that space, to foster a space of response-ability, a space which allows us to consider otherwise excluded otherness and act in turn.

117 Recognizing that every beginning is but another beginning’s end; origin is always fleeting and never achieved (see Barad, 2010; Derrida, 1976; Kirby, 2011).
I shared with Dr. Marker that what David Bohm did not seem to know at time\textsuperscript{118}: what he conceived of as a hypothesis and a theoretical language already had lived and long-lasting analogues in place. The similar yet different vocabulary of the ‘new physics’ that stretches the boundaries of Western science was part of the everyday (but differently articulated) vocabulary of Indigenous people:

A few months before his death, Bohm met with a number of Algon[qu]ian speakers and was struck by the perfect bridge between their language and worldview and his own exploration of philosophy. What to Bohm had been a more breakthrough in human though – quantum theory, relativity, his implicate order\textsuperscript{119} and rheomode – were part of the everyday life and speech of the Blackfoot, [Mi’kmaq], Cree, and Ojibwaj. (Peat, 2002, p. 238)

In (re)telling this story, to myself and to others, I am reminded once again of the always already present potential points of resonance from which an responsibility between WMS and Indigenous ways-of-knowing-in-being might be enacted within the multiplicitous spaces of science education\textsuperscript{120}. This, as Fleer (1997) argues, is not only a potentiality within science education but also one that is highly desirable for all students as “moving between world views creates high levels thinkers” (p. 17; see also van Eijck and Roth, 2009; Higgins, 2011). Because many Indigenous ways-of-knowing-in-being are based upon a reciprocal gift-based economy\textsuperscript{121} (see also Apffel-Marglin, 2011; Cajete, 1994; Kuokkanen, 2007), many diversely situated Indigenous scholars continue to remind of the existence and necessity of this potentially shared and productive pathway (e.g., Battiste, 2013b; Cajete, 2000; Donald, 2011). However, potentialities often vacillate between possibility and impossibility\textsuperscript{122} (see Barad, 2010, 2012). Part of this potentiality, as explored earlier, resides in the reception of otherness without subsuming, sublating, or suturing it over through moves

\textsuperscript{118} It is potentially the case that Bohm did not know because he could not know if the “lines of making sense” (Spivak, 1993/2009) were laid out such that science, particularly at the time, perceived IWL as wholly other.
\textsuperscript{119} The cautionary note here is that, as Barad (2010) reminds us, one is not enough and two is too many. Nonetheless, moving towards wholism from a location that is highly binary is a highly useful, even if only as rhetoric. Even if the goal is perhaps an impossible or undesirable location, the resulting push brings us closer to accounting for and being accountable to a world of intra-action which differentiates itself from and within itself such as it is articulated with/in Indigenous science (see Cajete, 1994, 2000).
\textsuperscript{120} This is a persistent theme throughout my work that vacillates between presence and absence. The ongoing dialectic of an Indigenous/Western binary perpetually sutures over this space of possibility while simultaneously being interrupted as porous binary. As such this hybrid space of potentiality is, for me, forever in the aporetic state of forgetfulness and remembrance.
\textsuperscript{121} Gift-based economies are in contrast to transactional models of economy based on logics of quantifiability and equivalence (see Apffel-Marglin, 2011; Kuokkanen, 2007). See previous chapter for further discussion.
\textsuperscript{122} Case-in-point, the Source for Educational Empowerment and Community Development (SEED) Dialogues (mentioned in the introduction) that became a more established and formalized version of the Science Dialogues that began in 1992 seem to have recently ended. These SEED dialogues focused on bringing scholars from different knowledge traditions to promote a form of learning from and with one another, notably with/in the space between Indigenous ways-of-knowing-in-being and established academic disciplines such as science and linguistics.
to sameness. It was and will never be enough to (de)construct new spaces, we must come to sustain the very things that sustain us (Haraway, 1997; Latour, 2004a). Recognizing the co-constitutive otherness that is Indigenous science to-come begets responsibilities of being-in-relation that stems from an ethics of (re)generation and reciprocity that sustains those relationships (see also Apffel-Marglin, 2011; Cajete, 1994, 1999, 2000; Kuokkanen, 2007).

Secondly, I tell this story to remind and remember responsibility never was and will never be an individual affair. My ability to respond is inevitably in relation with: those who have worked to respond before me, those with whom I have personal relations and with whom I labour, textual relations, as well as those who I may never come to know but whose work invariably plays out onto mine. In turn, the ability to respond must, by necessity, be distributed across relations as well:

There are no individual agents of change. Responsibility is not ours alone. And yet our responsibility is greater than it would be if it were ours alone. Responsibility entails an ongoing responsiveness to the entanglement of self and other, here and there, now and then. (Barad, 2007, p. 394)

While responsibility is shared by many, such a responsibility is not diffused and made lesser through its distribution but rather enhanced by it. How I know is intimately linked to how we know, not only potentially as a rich site of reciprocal meaning-making within a community of knowers (see Harding, 2004, 2009; Roth, 2003), but also in how the “I” and the “we” always already come to co-constitute one another (without ever becoming one and the same) within both prismatic and diffractive logics (see Barad, 2007, 2010; Deleuze, 1988; Foucault, 1977). As Barad (2007) suggests, responsibility is not simply a moral imperative but rather an ethico-onto-epistemological enactment that shapes and is shaped by our relational “being-of-the-world”:

our (intra)actions matter – each one reconfigures the world in its becoming – and yet they never leave us; they are sedimented into our becoming, they become us. And yet even in our becoming there is no ‘I’ separate from the intra-active becoming of the world. (Barad, 2007, p. 394)

We are and become with the very relations that precede us to which we are accountable (see also Butler, 2005; Cajete, 1994, 2000); the reason for which responsibility is not only distributed but also greater rather than lesser.

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123 Barad’s notion of being-of-the-world is a response to Heidegger’s being-in-the-world which necessitates an ‘I’ which precedes the relationship with the world, inevitably masking the conditions of emergence for the ‘I’ which notably only comes to be because there is a world from which it was never separated or separable (see Barad, 2007).

124 As Barad (2010) suggests, responsibility precedes us because it is produced with/in the co-constitutive relationships through which the ‘I’ of responsibility becomes:

Entanglements are relations of obligation–being bound to the other–enfolded traces of othering. Othering, the constitution of an ‘Other’, entails an indebtedness to the ‘Other’, who is irreducibly and materially bound to, threaded through, the ‘self’–a diffraction/dispersion of identity. (p. 265)
Lastly, and in turn, my relations of “self and other, here and there, now and then” (Barad, 2007, p. 394) that come to shape the “I” of responsibility cannot be thought of or enacted without the relations which come to constitute me. My very ability to respond is shaped by the complex ecology of relationships that constitute the “I” of responsibility and what becomes im/perceptible accordingly. Like Bohm in the story, I must continue to rework the very relational and situated norms of (im)perceptibility that come to shape the ability to respond (see Barad, 2010; Derrida, 1976). Rauna Kuokkanen (2007), whose work centers Western modern educational and institutional responsibility towards Indigenous ways-of-knowing-in-being, defines this Derridean double(d) meaning of response-ability as “an ability to respond, to respond to the world beyond oneself, as well as a willingness to recognize its existence” (Kuokkanen, 2007, p. 39). In turn, the possibility of being-in-relation is always already present should one do the “homework” required for such response-ability:

Doing homework is an ongoing practice that includes learning as much as possible about the area where the academic takes risks. However, familiarizing oneself with areas one knows little about still amounts to hegemonic practice if we do not engage in the “home” part of the homework. (Kuokkanen, 2007, p. 117)

It is for this reason that she highlights that the practice of taking risks must take place where it is potentially riskiest: “homework starts from where we are” (Kuokkanen, 2007, p. 117). Starting from where we are, can take many meanings: home as cultural, disciplinary, geographical, historical, among others. It is not only productively multiplicitous but also, as Derrida (1976) reminds, an inescapable and necessary condition:

The movements of deconstruction do not destroy structures from the outside. They are not possible and effective, nor can they take active aim, except by inhabiting those structures. Inhabiting them in a certain way, because one always inhabits, and all the more when one does not suspect it. Operating necessarily from the inside, borrowing all the strategic and economic resources of subversion from the old structure, borrowing them structurally, that is to say without being able to isolate their elements and atoms, the enterprise of deconstruction always in a certain way falls prey to its own work. (p. 24, emphasis mine)

The self does not come to be without an other; we are always indebted to the inheritance of the other to whom we are with/in relation, regardless of whether the self can or does respond to such responsibility (see also Butler, 2005). Butler (2005), along these lines rhetorically asks the following: “Does the postulation of a subject who is not self-grounding, that is, whose conditions of emergence can never be fully account for, undermine the possibility of responsibility and, in particular, of giving an account of oneself?” (p. 19). Where it is the common assumption that one must “know oneself” (as a stable, containable, and individualistic subject) in order to be morally responsible, Butler (2005) suggests that ethics can only emerge because the “I” of ethics only emerges with/in relation and that a self-contained self becomes a source of “‘moral narcissism’ whose pleasure resides in its ability to transcend the concrete world that conditions its actions and is affected by them” (p. 105). Relation begets and precedes responsibility; knowledge of a partially knowable self is still, nonetheless knowledge upon which one can act.
There is no outside of “where we are,” only the differential ability to respond to the relationality and responsibility that precede and shape us through critical inhabitation in a certain way: active engagement with the norms that structurally and invariably shape our becoming “all the more when one does not suspect it” (Derrida, 1976, p. 24; see also Spivak, 1976, 1993/2009). Of importance within this dissertation are the ever-present disciplinary spaces of science and science education. As Mazzochi (2006) states, within the context of cross-cultural scientific endeavours, that:

> We need to open ourselves to participating in the experience of others, and yet we should also be aware that this opening can only start from where we already are – from our point of view or the tradition to which we belong. (p. 465)

### 6.2.1 My relation to response-ability and/in decolonizing science education.

Response-ability is not simply or only the taking up of the responsibility that always already lay before us and constitute us, but also the iterative (re)opening of responsiveness towards the potentiality of perceiving and differently enacting possibilities and problematics within the distributive relations that we inherit and also are. In turn, as a Euro-settler trained within the physical sciences (specifically physics) and education, I recognize the importance of not simply rejecting my tradition’s epistemic, ontological and ethical commitments and enactments even (and especially) when they become problematic as this contextual vector always comes to bear on the potential (re)opening of responsiveness. To attempt to move beyond without working within and against runs the risk of reproducing its structures, strategies, processes and practices elsewhere, albeit differently (see Higgins, 2014a; Higgins, Madden, & Korteweg, 2015; McKinley, 2000; Sammel, 2009). I understand this move as an ongoing process of accounting for and being accountable to the knowledge traditions that continuously (re)produce me and my practice as educational researcher and science educator (Higgins, 2014a; see also Belczewski, 2009). Even as I engage in the work of reconstructing something that is beyond what science education is and is not, the work must nonetheless and paradoxically be within and against simultaneously. This is of particular significance given the deep gravitational pull of Cartesianism that makes it difficult to break from its epistemological and ontological orbits (Apffel-Marglin, 2011; Barad, 2007; Battiste, 2005; Braidotti, 2013).

To reiterate, response-ability, is not responsibility in the conventional sense; it is not something that one can simply take, give, or even have. Rather, response-ability is the double(d) process of (re)opening the space of responsiveness in order to enact that responsibilities towards the co-constitutive relationships we find ourselves in. Furthermore, response-ability is distributed along,
within, and throughout the relationships through which we are co-constituted. In turn (as mentioned in Chapters 3 and 5), there is no transcendental “I” who can irrupt the space of responsibility from outside: the work of response-ability is always within, against, and beyond the co-constitutive relations of the “I.” In the context of this dissertation, the “I” of science education research (i.e., the researcher) cannot be thought of without the co-constitutive disciplinary vectors that come to shape their response-ability. In addition, as Peat (2002) reminds us, some locations are more in/hospitable than others when it comes to the work of response-ability (see also Kuokannen, 2007; Spivak, 1988a). Points of resonance offer themselves, not as panaceas, but as vacillating spaces of possibility for the work of response-ability. Lastly, as response-ability is an ongoing and enacted process, it is generative to consider it with/in the space of theory-practice-ethics that is methodology. In the upcoming section, I flesh out response-ability as a methodological concept with which to think in the (im)possible reconstruction of science education to allow for Indigenous science to-come.

6.3 Doing the (Home)Work of Response-ability and/as Reconstructive Methodology:

Working Within, Against, and Beyond

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. It is an iterative (re)opening up to, an enabling of responsiveness. Not through the realization of some existing possibility, but through the iterative reworking of im/possibility, an ongoing rupturing, a cross-cutting of topological reconfiguring of the space of [response-ability]. (Barad, 2010, p. 265)

Here, Barad’s (2010) insights provide rich inroads towards ethically, epistemologically, and ontologically responding (and being able to respond) to the three facets identified with/in the earlier storied vignette. These insights are: response-ability as distributed and entangled, response-ability as (re)working possible possibilities, and responsibility as co-constitutive of the agencies of response-ability. As Barad (2010) suggests, echoing the reading of the lived story above, response-ability is the double(d) process of enabling responsiveness to enact the responsibilities which precedes and produces the “I” of responsibility. Response-ability, as an always iterative process without an origin that enfolds and unfolds the here-now and there-then, “is a relation always integral to the world’s ongoing intra-active becoming and not-becoming” (Barad, 2010, p. 265). In turn, as Barad (2010) suggests, the theory-practice-ethics of response-ability never achieves the calculable prescriptivity of conventional conceptions of responsibility but rather “require[s]/inspire[s] a new sense of a-count-ability, a new arithmetic, a new calculus” in which “one is too few, two is too many” (p. 251). She offers us methodological orientations towards doing the homework of response-ability and the
means to consider it as a (deconstructive/reconstructive methodology. Of particular significance here is the final sentence in which she states that response-ability is enacted “not through the realization of some existing possibility, but through the iterative reworking of im/possibility, an ongoing rupturing, a cross-cutting of topological reconfiguring of the space of response-ability.” (p. 265). For each of these insights, I will place them in conversation with previous chapters’ deconstructive approaches to differentially build upon them in relation to the ongoing project of (re)opening responsiveness towards Indigenous science to-come. Furthermore, I address how these entangled insights are taken up herein.

6.3.1 **Response-ability as ongoing rupturing.**

The notion of ongoing rupturing here signals, yet again, and unavoidably, deconstruction\(^\text{126}\). However, in marking and making the turn towards reconstruction, it is important to note the relationship between the two while chasing the possibility that, as Barad (2010) states, *one is too few* and *two is too many*. Deconstruction “is *not* about de-construction and re-construction” (Jackson & Mazzei, 2012, p. 15, emphasis in original); it is not a process of separation in which a separate agent brings in separable constituents. Rather, it is a process of differently arranging relations of co-constitutive otherness to which there is no outside from which total separation could occur. Thus, we can engage in the “undoing yet preserving of the opposition between” (Spivak, 1976, p. xix) this deconstructive/reconstructive binary opposition as they were never separate, nor separable. Not two, yet, importantly not one: there are still differentiations that come to mark the ways in which deconstruction differentiates itself from itself (i.e., never comes to be an *is*; see Spivak, 1993/2009; St. Pierre, 2011a). As Spivak (1993/2009) suggests, such a trajectory was marked in the way in which deconstruction was always already on the move within Derrida’s work: “the economy, in the early work, of protecting and preserving (*garder*) the question and, in the later, of its transformation into the call to the wholly-other (*tout-autre*)” (Spivak, 1993/2009, p. 109, emphasis in original).

Following a similar yet differing trajectory within this dissertation, response-ability as ongoing rupturing builds upon and differentially enacts the deconstructive moves of previous chapters. Notably, I differentially apply the deconstruction as critical and complicit (mis)readings put to work

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\(^{126}\) *Ongoing rupturing,* here, also signals the ways in which deconstruction *happens* (Jackson & Mazzei, 2012); the structure under erasure is always already in a state of ongoing rupturing. As such, the structure of science education cannot and should not be recognized as a closed form whose knowability precedes rupturing (despite claims otherwise). However, as with other deconstructive moves which stem from witnessing deconstruction, it is to pay attention to the deconstructive potentiality of irruptions as not all irruptive possibilities are desirable and not all are critically generative. Which is why Derrida (1976) reminds us that deconstruction critiques itself.
in the second chapter. Recall that critical and complicit (mis)reading is to work within and against a structure by differentially occupying it, by substituting what a concept, category, or construct is with what it is \textit{(not)}\footnote{Recall that \textit{is} \textit{(not)} signifies that which is otherwise unintended but still retains, albeit differently, the structure being critically inhabited (see Chapter 3).}. By substituting what it \textit{is} \textit{(not)}, that which could be signified by a signifier but usually is not (e.g., diffraction and prismatic dispersals as metaphors that come to replace and otherwise signify the optics of critique which operate through mirroring; see Chapter 3), differential possibilities emerge which are neither same nor wholly different by retaining (a partially erased trace of) the structure (see Derrida, 1976; Spivak, 1993/2009).

Furthermore, the task of deconstructive (mis)readings requires locating self-transgressive moments (i.e., where meaning vacillates intended meanings and its excessive constitutive otherness) in and from which to pry open the structure under erasure (Spivak, 1976). As discussed in Chapter 3, such locations are ripe for (mis)readings as that which it \textit{is} \textit{(not)} already comes to bear as excess; an intentional (mis)reading becomes but a leveraging of the deconstructive possibility to (re)open the structure under erasure. As deconstructive reconstruction must inevitably be within the very structure that (re)produces me, I draw from these insights to continue to critically and complicitly occupy science education, targeting the “home” of homework that is response-ability. In particular, I look to differentially signify two key locations with/in science curriculum and pedagogy that are paradoxically central yet taken-for-granted: notably scientific literacy (the curricular goal of science education) and visuality (the primary sense through which science education pedagogy operates, targeting photovoice as a rich visual pedagogy in science education). This is to be achieved by doing the labour of (mis)reading these locations by substituting that which each \textit{is} \textit{(not)}. This work begins by substituting that retains a trace of the (partially erased) structure by drawing in strongly similar yet different iterations of that which is being substituted. Notably, I (re)consider scientific literacy as agential literacy as a means of learning WMS, as well as (re)signify photovoice using more contemporary iterations of the very theories which constitute it.

However, “deconstruction is [and can be] more than working within and against a structure” (St. Pierre, 2011a, p. 613) by substituting similar yet different meanings that retain the resources of the structure; “it is also the overturning and displacement of a structure so that something(s) different can be thought/done” (St. Pierre, 2011a, p. 613). The previous deconstructive approaches are not sufficient if the reconstructive orientation is to bring in Indigenous priorities, pedagogies, and
protocols so that they might come to bear; requiring of science educators that “we radically de-naturalize what we’ve taken for granted. Here we refuse alternatives and pursue the *supplement* [i.e., the wholly other, the to-come], what always already escapes the structure” (St. Pierre, 2011a, p. 613). Here, we can turn to Barad’s second suggestion.

### 6.3.2 Response-ability as a cross-cutting of topological reconfiguring.

Barad (2007) suggests that the potentiality of deconstructive work does not lay strictly in its ability to identify the constitutive otherness of concepts, categories, and constructs. Nor does its possibility wholly reside in the always already occurring rupturing and shifting of meaning. Also, deconstruction acts as an ongoing invitation towards an engaged act of account- and response-ability towards constitutive otherness, as well as an ever-present possibility to re(con)figure the lines of inclusion/exclusion, (re)constructing with that which was excluded (e.g., see Chapters 4 and 5’s account-ability towards WMS’ co-constitutive knowings, beings, and ethics). As the exclusion of constitutive otherness always comes-to-be, the work of deconstructing and reconstructing continues to be a recursive, iterative, and co-constitutive process which stems from the possibilities that arise from relationality. On the subject of relationality, Kirby (2011) reminds us that:

> Relationality is not an “in-between” the *de-tailing* of entities. If the Earth’s grammar is necessarily internal, a shifting algorithm, than any “part” of the Earth would be a virtual geometry with hologrammatic resonance rather than a separated entity, broken off from its larger and now absent, or perhaps still attached totality. (p. 39, emphasis in original)

In *Quantum Anthropologies*, Vicky Kirby (2011) re-reads Derrida’s (1976) iconic statement that “there is nothing outside the text” (Derrida, 1976, p. 163) by juxtaposing it to the earlier one that there is “[no] outside of metaphysics” (Derrida, 1976, p. 19) to consider the ways in which “there is no outside of Nature” (Kirby, 2011, p. 38). This is “not to suggest that we need to ‘get real’ and add Nature’s authorship to this strange text as if Culture’s inadequacies might be healed by a natural supplement” (p. 13). Rather as in the above block quotation by Kirby, it is to explore a relational conception of the world in which Derridean relationality does not preclude Nature. By refusing to revert Nature to a pre-critical status and to consider Nature and Culture as separate and separable, Kirby suggests Nature-Culture as a constitutive wholeness that never achieves one-ness. From this, relationality emerges not as the by-product of entities (i.e., de-tailing) but is the always already

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128 This is of particular significance within science education where post-structuralism’s primary focus on Culture and cultural indetermination have made it such that a *too simple* reading of these approaches can be read as a jettisoning of the very concept of science: knowing nature, as well as knowing Nature (i.e., the metaphysical relation between space, time, and matter; see Barad, 2011).
active constitution of a co-constitutive part/whole (see also Barad, 2007, 2010, Cajete, 1994; Peat, 2002). In turn, the task of response-ability is not to place peoples, places, and processes in relation: they are always in relation. These relations, as Barad (2010) reminds us, are shaped by a constant reworking of the norms of exclusion and inclusion that come to form a topology of cross-cuts, lines that come to shape what (temporarily) is and is not, as well as could be and the degree to which parts of the whole come to be on another part. However, because the cuts are agential, there is always the possibility of reworking how, where, and when they are made to bring seemingly distant natural-cultural elements into a relation of proximity.

To do this (home)work of response-ability, I extend the deconstructive tinkering of Chapters 4 and 5. This is of particular significance as Chapters 4 and 5 also explored the technologies of power that produced metaphysical distance between that which was in a relation of natural-cultural proximity (e.g., abstracting one’s own body as labour in the proto-market economy, the enclosure and the encloser’s advantage; see Apffel-Marglin, 2011); the (home)work of response-ability can be thought of and enacted as a practice that works to bring that which is distant into proximal relation. As Barad (2010) asks, “what if we were to recognize that differentiating is a material act that is not about radical separation [and distance], but on the contrary, about making connections and commitments?” (p. 266).

To quickly recap (from Chapter 4), deconstructive tinkering is first and foremost a process of reversing and (re)opening the engineering/bricolage binary through: a) the use of tools otherwise unintended for the task at hand; b) using intended tools in ways they were not intended; and privileging the process over the product as the “product” of knowledge creation never (fully) comes to be (see Derrida, 1976). However, response-ability as reconfiguring a topology of cross-cutting encourages a (re)consideration of inside/outside: there is no “outside” from which to draw the tools with which the bricoleur (i.e., the tinkerer) labours but rather only new ways of differently connecting that which is already there. Within this chapter, I tinker with Indigenous-ways-of-living-with-nature not as the end result (although bricolage is always to be criticized by what is and can be

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129 As Donald (2011) remarks, because there already exists an Indigenous-Western relationality which is often but not always marked by coloniality, there is always the possibility of enacting it anew, differently, with a decolonizing ethic. Furthermore, as explored within the previous chapter, even the “One Truth” of science is inevitably related to the very things that it oppositionally defines itself against.

130 This is not unlike the current geopolitical lines that are entangled with/in nationhood. These, as Marker (2015) reminds by drawing from Coast Salish peoples’ navigation of the US-Canada border, are cultural enactments that do not transcend culture but are rather entangled with/in culture (i.e., Coast Salish people enact a differential spatial enactment of who they are which exceeds and is exceeded by current geo-political conditions).
engineered), but as part of the process as these ancestral and longstanding practices were never developed for the purpose of school science. Nonetheless, they offer rich tools for school science to be (re)thought and enacted otherwise.

Such a deconstruction of the topological norms of inclusion/exclusion is, as explored in the previous approach for (re)opening response-ability, a way of working not only within and against a structure but also beyond (a beyond that is nonetheless with/in the whole). However, while deconstruction is always already happening (whether we witness it or not), what comes to occupy this differential opening is often but a simulacrum: a different similarity or a similar difference (see Higgins, Madden, & Korteweg, 2015; Mazzei, 2007). While Barad (2010) suggests that, “only in this ongoing responsibility to the entangled other, without dismissal (without ‘enough already!’), is there the possibility of justice-to-come” (pp. 264-265), there is nonetheless strategic and tactical locations from which to do the (home)work of responsibility. Here, a third approach can help in reworking and leveraging this open-ended closure.

6.3.3 Response-ability as the iterative reworking of im/possibility.

As mentioned within the very beginning of the chapter, dialogue between IWLN and WMS is in a perpetual state of im/possibility: they are not and never will be (fully) commensurate (see Cajete, 1994, 2000; Barnhardt & Kawagley, 2005, 2008; Peat, 2002). This, in turn, complicates the possibility of if and how IWLN and TEK are included with/in school science. Generously and generatively, Spivak (1993/2009) asks, What becomes possible when we persistently labour the conditions of im/possibility? In considering response-ability as the iterative reworking of im/possibility, it is important to recognize that the “field of possibilities is not static or singular but rather is a dynamic and contingent multiplicity” (Barad, 2007, p. 147). In other words, possibilities do not sit still and some possibilities are more possible than others.

Locating such possible possibilities is the work of what Cajete (1994) refers to as “creative acts of perception” (p. 19). Elsewhere, Cajete (2000) qualifies that “the idea of moving around to look from a different perspective… is contained in the creative process. Indigenous logic moves between relationships, revisiting, moving to where it is necessary to learn or to bring understandings

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131 While one of the ways in which the deconstruction that is always already happening can be read is in the inevitable rupturing of any and every structure, it does not always come to present the norms of power through which the structure comes to (re)produce itself as a simulacrum of its former self. Elsewhere (Higgins, Madden, & Korteweg, 2015), I noticed the ways in which teachers who began the inclusion of Indigenous materials in their teaching practice differently articulated coloniality (e.g., presenting an image of Indigenous peoples as pan- Indigenous and of a past already past). Such rearticulates the need to continuously focus on a process as opposed to a product (e.g., a “decolonized” curriculum which may come to mask the ways in which it continues to uphold colonialism; see also Carter, 2004, 2010).
together” (Cajete, 2000, p. 210). This idea of approaching from multiple angles provides a productive extension to the play of (re)signification that was called upon in Chapter 2. In short, the play of (re)signification signals the ways in which deconstruction is an always extended invitation to consider other possible possibilities that might take hold stemming from the inevitability of theory-practice being exceeded and self-deconstructing. Drawing from Barad, and extending my own deconstructive work that began elsewhere (Higgins, Madden, and Korteweg, 2015), I consider deconstruction of not only binary nodes (e.g., self/other and familiar/strange), but also of binary relationships between multiple binaries (e.g., self+familiar/other+strange).

Drawing on these insights, I was on the lookout for moments in which science education’s meanings vacillate in ways that might (re)open its structures through deconstruction. While on the lookout for snags within the structure of science education (eventually identified as scientific literacy and visuality), I held awareness of the possibility of a reversal of a (porous) Western/Indigenous binary. In other words, I revisited the questions, Where might tinkering with IWLN allow for the most productive (mis)readings of science education? Where might similar yet different Indigenous theory-practices come to differentially occupy this (re)opening so that Indigenous science to come might take hold. I was inevitably searching for productive points of resonance that could be levered to prevent the structure from too easily suturing itself over, reverting to a state of self-sameness. However, iteratively, it is important to note the dangers of subsuming otherness into sameness:

the wholly other, le tout-autre, cannot be selved or samed. It is not susceptible to ipseïté or mêmeté. The face of the wholly-other is without a name. The “other” that we narrativize or grasp consolidates the self, through a kind of stade du miroir [Mirror stage\(^\text{132}\)] (Spivak, 1993/2009, p. 238)

That which is (not) science, such as IWLN and TEK, simultaneously existing with/in science education and yet not, as always to-come, loses its radical potentiality when it comes to bear through dialectic relations (see Chapter 2). Such a sameness must be used and troubled; refusing the (full) reversal of difference as (wholly) separate, separable, and outside of relationality.

6.4 Science Curriculum and Response-Ability: Re(con)figuring Scientific Literacy

In this section, I labour the space of response-ability within, against, and beyond the primary curricular node of science education: scientific literacy. Within the first part (i.e., Response-ability as ongoing rupturing), I identify scientific literacy as a central yet uncertain concept whose critical

\(^{132}\)The mirror stage, drawing from Lacanian psycho-analytics, is when the Imaginary we hold dialectically (in)takes the Real, producing cuts which prevent the wholly other from being anything more than what can already be known. This is of particular relevance considering the ways in which IWLN and TEK are often only considered science when they fit the criteria of "valid" science (which often happens to be that of WMS).
inhabitation is ripe for other meanings and enactments. In the second part (i.e., Response-ability as the iterative reworking of im/possibility), I identify Karen Barad’s subversion of scientific literacy as agential literacy as a productive location to rework the connectivity towards IWLN and TEK. In the third section (i.e., Response-ability as the cross-cutting of topological reconfiguring), I utilize agential literacy as proximal (yet differing) relation to bring in Gregory Cajete’s conception of Indigenous science as ecologies of relationships. Lastly, I add a cautionary note on points of convergence and points of divergence, wherein I use and trouble the proximal relation between agential literacy and ecologies of relationships by suggesting that this should not be recoded as but a new location for the mirror of sameness to take hold.

6.4.1 Response-ability as ongoing rupturing: Scientific literacy as central yet uncertain.

As Barad (2000) states about scientific literacy, its importance to science education is central while its very purpose is always on the move:

There has been no shortage of rationales given on behalf of the national need for scientific literacy. Scientific literacy has been hailed as: the basis for democratic decision making about public issues; necessary for global economic competitiveness and national security; crucial for the promotion of rational thinking; a condition for cultural literacy; necessary for gainful employment in an increasingly technological world; the basis for personal decision making about health-related issues; and necessary for the maintenance of the public image of science. (Barad, 2000, p. 225)

Scientific literacy has become ubiquitous within and almost synonymous with science education (Aikenhead, 2006a; Barad, 2000; Holbrook & Rannikmae, 2007; Roth, 2003). Following over four decades of use, it has become unavoidable, central, as well as the “conventional” goal of science education (Aikenhead & Elliot, 2010; Holbrook & Rannikmae, 2009). Almost anthemic, call for scientific literacy for all rings out across educational institutions and levels (e.g., curricular resources, policy). As Barad (2000) states above, there is no lack of reasons for which scientific literacy is leveraged and centered within science education; however, she asks: “what does it mean to be scientifically literate?” (p. 225).

As Roth (2003) states, “the concept of scientific literacy is itself not at all clear” (p. 11). This is not to say that it holds a meaning that is itself blurry, rather, one that might be described as ambivalent, pluralistic, and in ways that come to occasionally contradict themselves. As Holbrook and Rannikmae (2009) state, scientific literacy is inhabited by a multiplicity of conceptual components:

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133 So much so that Holbrook and Rannikmae (2009) go on to state that despite the prevalence of the term, there are science educators who would prefer the adoption of more conceptually precise terms in its stead.
(a) Knowledge of the substantive content of science and the ability to distinguish from non-science; (b) Understanding science and its applications; (c) Knowledge of what counts as science; (d) Independence in learning science; (e) Ability to think scientifically; (f) Ability to use scientific knowledge in problem solving; (g) Knowledge needed for intelligent participation in science-based issues; (h) Understanding the nature of science, including its relationship with culture; (i) Appreciation of and comfort with science, including its wonder and curiosity; (j) Knowledge of the risks and benefits of science; and (k) Ability to think critically about science and to deal with scientific expertise.

The conceptual components found within this non-exhaustive list are not only differentially included/excluded but also non-uniformly enacted through following the curricular goal that is scientific literacy. It is for this reason that they state scientific literacy has been so successful in its proliferation: it “avoids the use of distracting detail and, as such, convincingly portrays a complex idea which intuitively appears to be correct” (Holbrook & Rannikmae, 2009, p. 275). Here, we find resonance with Davis (2008) who states that some of the concepts that are the most successful in achieving a degree of everywhere-ness by reaching wide academic audiences and circulation are those that are at once ambiguous and incomplete.134

Despite the conceptual ambiguity presented with/in scientific literacy, Barad (2000) states that, “most commonly, scientific literacy is thought of in terms of the successful transmission of knowledge about scientific facts and methods from knowing scientists to the ignorant masses” (p. 226, emphasis mine)135. Most commonly here signals the ways in which there is a (i.e., singular) common sense: a common sense that is at once held and by which science education and educators are held (see Chapter 4). As van Eijck and Roth (2007) remind us, drawing from Foucault (1977, 1979), the logics of science education can often be characterized as a “regime of truth.” As explored in Chapters 4 and 5, regimes of truth are marked by circular relations: each “truth” is but a differential articulation of the systems of power which produces it, whose articulation in turn (re)produces the systems of power. Such a circular relation can be read in two ways: first, as signaling a hermetic circle, a (fore)closure of knowledge (as in Chapter 2); and second, as the capillary circulation of power from one conceptual node to another (see Chapter 3).136

134 Davis (2008) makes the case for the popularity and pervasiveness of the concept of intersectionality in the social sciences.
135 Not only this, but Roth (2003) reminds us that these facts are but “a faint and distorted image of scientists’ science.” (p. 10; see also Aikenhead & Michell, 2011; Aikenhead & Ogawa, 2007; McComas, 1998). Furthermore, scientific literacy is complicated by the notion that “it is assumed that it is the scientists’ place to define what should be known in the field. Why should this be when at other times and places scientists claim a lack of interest in how science is used and taught?” (Roth, 2003, p. 12; see also Barad, 2000). The stance of Modest Witness (explored in the previous chapter) that is often held by the subject of scientific inquiry is diametrically at odds with the subject of education to whom they are accountable to(wards).
136 It is not uncommon to see statements like the following: “A common rationale given for studying science subjects in
ambivalence and the ever-present possibility of deconstructive (re)signification, it is no surprise that scientific literacy is, for the most part, (re)produced within and reproducing the norms of power of science education (see Higgins, 2014a; McKinley, 2000, 2007; Sammel, 2009; van Eijck & Roth, 2007). There has been a major paradigmatic shift in science education in the last decades which shifts the emphasis from coming to know what scientists know (i.e., cognitivism, intra-personal learning, scientific knowledge as representation of nature) to enculturation into how scientists come-to-know (i.e. socio-constructivism, inter-personal learning, scientific knowledge as representation of culture) (see Barad, 2000; Erickson, 2001; Aikenhead, 2006a); as Holbrook and Rannikmae (2007) state: “no content is fundamental, but rather the content needed for enhancing scientific literacy is dependent on the culture and society in which the science education is implemented” (p. 1352).

However, the “teaching practices have changed little and remain based on traditional, universalist views of science and science education” (McKinley, 2007, p. 219); common sense understandings of science, scientist, and science education most commonly come to fill these (re)opening locations (see also McKinley, 2000; Sammel, 2009).

Paradoxically, in light of the ambiguity of scientific literacy, only a small fraction of the population can be said to be scientifically literate (Barad, 2000, 2012a). Barad (2000) states:

viewed in this way, the problem of scientific illiteracy is seen as a massive transmission failure... In light of the extraordinary monetary and intellectual resources that have been and continue to be committed to solving this problem, it is perhaps not unreasonable to ask if the metaphor itself isn’t sending the wrong signal (p. 226)

As Holbrook and Rannikmae (2009) suggest, “the core of the idea behind scientific literacy lies in its analogy with literacy” (p. 275). By invoking literacy as a metaphor, we invoke a common sense notion that to be scientifically literate is to be able to read, interpret, and determine the validity of a multiplicity of scientific texts: scientific documentation and instrumentation, reporting on past, current, and future socio-scientific issues, the cultural practice of science, as well as Nature itself. This, as Barad (2000) states, might be “sending the wrong signal” (p. 226); a signal which in turn (re)produces science education as an enactment and a (re)producing of what Barad (2007) refers to as a metaphysics of individualism (see Chapters 4 and 5). This makes scientific literacy a location

school is the achievement of scientific literacy” (Holbrook & Rannikmae, 2007, p. 1347). However, when the most common understanding of scientific literacy is “studying science,” such statements achieve a certain circularity (in both senses) by distributing its collective meaning across its similar yet different articulations of science-as-usual (Roth, 2003; van Eijck & Roth, 2007).
that is at once inadequate yet necessary, and ripe for the ongoing rupturing of response-ability through critical inhabitation for (at least) three reasons.

First, the metaphor of literacy invites a metaphysics of individualism by calling upon reading and hermeneutics: the reader is both separate and separable from the scientific “text,” both of which ontologically precede the act of reading. Furthermore, interpretive readings in/of science generally requires that the reader learn through mirroring the text (when decreed as valid science) or dialectically negating the text. Secondly, the metaphor of literacy reinforces the notion that learning to be scientifically literate is an individual affair. Similarly to the ways in which we consider the act of reading as a mathematical set in which there is one reader and one text, the oft-exclaimed scientific literacy for all presupposes that each and every learner has an individualistic relationship with scientific literacy and that each and every text is different. As Roth (2003) states, this educational separation between both learner, text, and other texts produce the precondition for a problematic double(d) effect:

Scientific literacy currently means to question nature in ways such that do not, reflexively, also question science and scientists. However, worse is the other part of the current rhetoric about scientific literacy—it is to be for all. All individuals (e.g. Americans), so goes the idealist rhetoric, have to learn and exhibit certain ‘basic’ facts and skills. Just imagine, every individual taking the same (‘scientific’) perspective on GMOs, genetic manipulation of the human genome, or use of drugs (such as those used to dope certain kinds of children, labelled ‘ADHD’ (i.e. Attention-deficit, hyperactive disorder) to make them compliant). (p. 11)

In other words, the focusing of each and every student on “one” text (i.e., the science-as-usual curriculum)\(^\text{137}\) that is treated as separate and separable from other texts (e.g., scientific ethics) produces scientific literacy as, by design, un-self-reflexive. While the possibility of ethical self-reflexivity is not wholly foreclosed, it is evident that practices of scientific-literacy-as-usual focuses primarily on the ways in which different students (through standardized testing) achieve different levels of attainment of the same curricular content. Furthermore, Roth (2003) appeals to curricular reason when he states that “we [science educators] all know that there simply exists too much specific knowledge for any individual to know the relevant facts even in more constrained contexts” (Roth, 2003, p. 19). Third, like with reading, texts can be selected to be relevant to each and every reader in order to achieve scientific literacy for all. However, Barad (2000) cautions that “there’s something paradoxical about the notion that something can be ‘made’ relevant – as if relevancy

\(^{137}\) However, even a science-as-usual curriculum fails to achieve one-ness as it is always already co-constituted by a variety of texts: both intentionally (e.g., sources) and unintentionally (e.g., the relational act of reading is inter-textual and brings other texts to bear on the meaning made).
could be imposed or added onto an existing structure” (p. 221). This signals the differentiation between how relevancy often plays out between theory and practice (or more appropriately how, as Lenz-Taguchi (2010) suggests, theory is always already entangled within practice; see also Spivak, 1988a); scientific texts can become what Barad (2000) refers to as “context-coated.” This, as signaled within the previous chapter, can reduce epistemic pluralism in science education as but different ways of achieving the same ontological location: knowing nature with/in Cartesianism. In turn, as Roth (2003) suggests, “there is more than one reason to rethink scientific literacy and to see it as an emergent collective praxis” (p. 21); scientific literacy need not presuppose a metaphysics of individualism from the get-go. Rather, “if we think of scientific literacy in different terms, as choreography of a particular kind in which we learn to participate by participating from the beginning, we take radically different approaches to teaching science in schools” (Roth, 2003, p. 19). Not unlike Chapter 3, in which critique is re(con)figured to address its normative enactments of distance and separation as the condition for knowledge, as well as the pre-epistemic and pre-ontological status of the object and subject of critique, I turn to Barad (2000, 2007, 2012b) to think scientific literacy otherwise.

6.4.2 Response-ability the iterative reworking of im/possibility: Karen Barad’s shift from scientific literacy to agential literacy.

Drawing from quantum physics, Barad’s (2007, 2012b) theory of agential realism provides a rich location to iteratively rework the norms of im/possibility by working within and against science and science education to produce a location that might differentially allow IWLN to take hold (i.e., take hold in ways in which it has not already, beyond integration and tolerance). Agential realism, as Barad theorizes it, questions the humanist a priori status of nature before culture, as well as the anti-humanist corollary statement of culture before nature (Barad, 2007; Kirby, 2011). This work disrupts the notion that Cartesianism is the (only) ontology, not by negating it but rather by positioning it as one ontological configuration among many. These configurations are presented and produced as open-ended processes that are enacted rather than static. In particular, Barad’s concept of intra-action enables us to gain insight into how relationality, flux and process are conceptualized and enacted:

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. (Barad, 2007, p. 33)
In other words, intra-action accounts for and is accountable to the various ways in which bodies of meaning (e.g., social, cultural, political, historical) and bodies of matter (e.g., biology, ecology, physics, engineering, architecture) are co-constitutive. This acts as an invitation to consider the ways in which these bodies of meaning-matter are not only produced through Cartesian norms of bodily production (i.e., subjects and objects) but also through other-than-Cartesian entanglements that would comprise and cut across multiple Cartesian subjects and objects. This is not simply a way of redrawing the lines of bodily production (e.g., researcher + instrument interaction –> researcher-instrument intra-active entanglement), it is also a (re)consideration of how they come into being. As Barad (2012c) states,

A quantum ontology deconstructs the classical one: there are no pre-existing individual objects with determinate boundaries and properties that precede some interaction, nor are there any concepts with determinate meanings that could be used to describe their behavior; rather determinate boundaries and properties of objects-within-phenomena, and determinate contingent meanings, are enacted through specific intra-actions, where phenomena are the ontological inseparability of intra-acting agencies. (pp. 6-7)

Accordingly, the production of natural-cultural bodies and their bodily norms are enacted, in flux, process-based and performative rather than something that always already is (or is not). Because phenomena are constitutive of reality, being can be thought as a performative and co-constitutive becoming: “reality is composed not of things-in-themselves or things-behind phenomena but of things-in-phenomena” (Barad, 2007, p. 140).

The consequences of agential realism for scientific literacy are drastic. The task of epistemologically establishing a representational (i.e., humanist) relationship of equivalence with either nature (i.e., through cognitivism) or culture (i.e., through socio-constructivism) breaks down because their separation was never a priori. Rather, Barad (2000) invites us to consider how “scientific literacy becomes a matter of agential literacy – of learning how to intra-act responsibly within the world” (p. 237) around the matters of science (i.e., space, time, and matter). This is significant as agential literacy goes beyond scientific literacy’s accounting for the diverse natural and cultural agents that constitute experimental phenomena studied and produced within the context of science education. First, it considers the ways in which agents are always already natural-cultural. Secondly, it accounts for the ways in which these agents not only constitute but are also constituted by phenomena. Third, agential literacy ethically re(con)figures accountability as a process of not only accounting for, but also being accountable to these agents and their intra-action in the world’s ongoing becoming.
6.4.3 Response-ability as the cross-cutting of topological re(con)figuring: Gregory Cajete’s Indigenous ways-of-knowing-in-being and science curriculum as all my relations.

Leveraging this differential opening into WMS and, in turn, science education allows for the possibility to cross-cut the topology which presents WMS and IWLN as distant by bringing them into proximal relation. Articulating relationality, flux and process differently and for different purposes, Indigenous science educator Cajete (1994, 1999, 2000) proposes that we consider ways-of-knowing-in-being – that is, the co-substantiation of epistemology and ontology – as ecologies of relationships. These ecologies of relationships that are enacted with/in these ways-of-knowing-in-being are often referred to as both external and internal to a human(ist) subject, while noting that some of the relations external to the subject do not require a subject at all\textsuperscript{138}. Externally, we often speak of relationships with other humans, relationships with other-than-human bodies (e.g., plants, rivers, mountains), as well as relationships with more-than-human bodies (i.e., spiritual beings) (see also Apffel-Marglin, 2011). Internally, the relationships between heart, mind, body and spirit are often called upon.

Furthermore, the boundary between exteriority and interiority is one that is porous, and it is this porosity that allows us to be with/in relation. This ontological porosity extends to space and time to make being in the world a question of process, flux and holistically being of the world rather than in. As Cajete (1994) states, “a constant building upon earlier realities is a basic characteristic of Indigenous processes ... [in which] we engineer the new reality built upon earlier ones, while simultaneously addressing the needs, and acting in the sun, of our times” (p. 27). The intentionality here signals that Cajete’s ecology of relationships (sometimes referred to as “sense of place”) is not simply a way-of-knowing-in-being in which the world is enacted through the flux of relationships, but that there is also an ongoing accounting for and accountability to the ecology of relationships.

\textsuperscript{138} As Cajete (2000) states, Indigenous ways-of-knowing-in-being entail a “reciprocal compact of care and responsibility” (p. 183) that is an ongoing enactment (rather than an ontologically pre-existing quality) that is deeply creative, co-constitutive, and relational. However, this enactment is not one that is only human, or necessarily co-constituted with humans:

Creative use of the environment guaranteed its continuity, and Indigenous peoples understood the importance of allowing their land its rich life because they believed their land understood the value of using humans. If humans could use the land, the land would also use them to enrich it and keep it alive. They and the place they lived were equal partners in life. (Cajete, 2000, p. 204)

It is one that is also co-constitutively enacted by the various beings, both other-than-human and more-than-human, which come to inhabit an ecology of relationships (see also Apffel-Marglin, 2011; Cajete, 1994).
such that it is (re)generated and sustained\textsuperscript{139}. It is for this reason that Cajete (2000) reminds us that within many Indigenous languages there is an expression akin to “all my relations” (e.g., \textit{Mitakuye Oyasin} in Lakota). “All my relations” is an epistemological, ontological and ethical accounting for and being accountable to the ecologies of relationships we find ourselves in and constituted by which extends beyond the immediate present to include generations past and those still yet-to-come. It is a metaphysical principle through and by which Indigenous “people understood [and understand] that all entities of nature – plants, animals, stones, trees, mountains, rivers, lakes and a host of other living entities – are embodied [and co-constitutive] relationships that must be honoured” (Cajete, 2000, p. 178).

An Indigenous “science education curriculum” of “all my relations” has been in place since time immemorial in the form of land- or place-based education (Cajete, 1994, 1999, 2000; see also Aikenhead & Michell, 2011; Barnhardt & Kawagley, 2005, 2008). Despite disruption by ongoing (neo-)colonial practices, Cajete (2000) reminds us that Indigenous knowledge holders continue to engage these traditional yet ever evolving contemporary ways-of-knowing-in-being by “seeking, making, sharing, and celebrating” (p. 178) the ecological relationships they find themselves with/in\textsuperscript{140}. Accordingly, with/in Cajete’s (1994, 1999, 2000) conception of Indigenous science education, scientific literacy would not simply be a task of knowing \textit{about} nature but rather knowing-in-being \textit{with} nature as an inseparable and co-constitutive part of the ecologies of

\textsuperscript{139} As Cajete (2000) suggests, such accounting for and accountability to the ecology of relationships has much to do with the notion that these relations are the pre-condition for Indigenous ways-of-knowing-in-being rather than simply a choice that is chosen or taken up by separate and separable entities:

\begin{quote}
The land nurtures humans and humans nurture the land, the foundation of a reciprocal compact of care and responsibility, which is continually reaffirmed through the various expressions of Native technology. Given this special relationship, the separation of culture and nature would be considered unnatural. Likewise, the separation of humankind from nature and the creation of discrete categories for viewing nature inherent in [most of] the disciplines of Western science would be viewed as equally unnatural and arbitrary (p. 183).
\end{quote}

Extending this, the Nature/Culture binary is not only a (neo-)colonial imposition, but furthermore, as mentioned throughout, reading the world through such a binary fails to account for the ways in which knowing (i.e., epistemology) and being (i.e., ontology) are entangled within Indigenous ways-of-knowing-in-being (Cajete, 2000; see also Apffel-Marglin, 2011; Bang & Marin, 2015).

\textsuperscript{140} Castellano (2000) outlines three foundations of Indigenous knowledge: \textit{traditional} knowledge (intergenerational), \textit{empirical} knowledge (gained through careful observation), and \textit{revealed} knowledge (acquired through dreams, visions, and intuitions). To these three Cajete (2009) added a fourth: \textit{modern} knowledge. This last foundation involves the participation in “modern” practices so that it may complement the other foundations. It is important to recall that modernity does not always entail Western modernity. As scientific and technological products and processes are taken up, the often-held assumption is that they remain unaffected. Instead, what traditions these scientific technologies suture over and, more important, how these technologies are shaped by these traditions should be considered (see also Gough, 2006; Harding, 2008; Nakata, 2007a).
relationships in order to learn “the subtle, but all important, language of relationship” (Cajete, 2000, p. 178).

This teaching of knowing-in-being with is woven into and enacted through traditional Indigenous approaches to teaching and learning, such as storywork. As Barnhardt and Kawagley (2008) remind us, while Indigenous stories hold rich representations of nature (i.e., knowledge about nature when read with/in Cartesian representationalism), their potential lies in honouring a knowing-in-being with the plants, the animals and a wide range of other-than-human bodies that are teachers with/in the ecologies of relationships particular to a place. As a pedagogy through which Indigenous peoples “came [and come] to perceive themselves as living in a sea of relationships” (Cajete, 2000, p. 178), it is a way to witness already existing relations and foster the possibility of new ones.

6.4.4 A cautionary note on points of convergence and points of divergence: using yet refusing sameness.

Through the potentiality of this proximal relation, it becomes productive to explore both similar differences and differing similarities (see Bohm, 1994). As Barnhardt and Kawagley (2005) offer this was and is already happening: “there is a growing appreciation of the complementarity that exists between what were previously considered two disparate and irreconcilable systems of thought” (p. 12)\(^{141}\). As one location, Peat (2002) suggests there are rich points of resonance between the Indigenous ways-of-knowing-in-being and the quantum physics phenomena:

> It is at this point that a tantalizing paradox presents itself. On one hand it seems that the very activity and busy-ness of our analytic, linear Western minds would obstruct us from entering into Indigenous coming-to-knowing, yet, on the other, scientists who have been struggling at the cutting edges of their fields have come up with concepts that resonate with those of Indigenous science. (p. 6)

However, while there are deep and productive points of resonance between quantum and Indigenous ontologies, there are still patterns of difference that matter. To uniquely focus on commensurability is to employ the metaphor of the mirror discussed in Chapter 3. Commensurability then becomes an act of mirroring sameness elsewhere, dialectically subsuming into or sublating through sameness patterns of difference, as well as making it difficult to account for and be accountable to the enactment of difference (Barad, 2007, 2010; Latour, 2004; Lenz-Taguichi, 2010). Relationships of

\(^{141}\) There are also many already present spaces that have been masked through their dialectic negation. Here are but three examples that I am familiar with. First, a more situated naming of Maslow’s hierarchy of needs might be Maslow’s (mis)interpretation of a hierarchy of Blackfoot needs from his time spent with the Blackfoot when he was “stuck” on his working developmental theory (Blackstock, 2011). Secondly, aspirin is the synthetic simile of a willow-bark based traditional medicine that was “discovered” by the Bayer pharmaceutical company (Snively & Corsiglia, 2001). Third, as Cajete (2000) states, Native Americans had a central role in “establishing uses for asphalt and other petroleum products” (p. 190) such as petroleum jelly as a salve for treating burns and open wounds and asphalt as a waterproofing material.
commensurability become all the more complicated between Indigenous and Western ways-of-knowing-in-being: equivocation often becomes a move to mask colonial relations of power between the two (Carter, 2004). As explored within earlier chapters, science education is not a space that is exempt from this occurrence (e.g., Carter, 2004; McKinley, 2000, 2007; Sammel, 2009). However, rather than adopt a position of *incommensurability* when considering the space between WMS, TEK, and IWLN, Cajete (2000) suggests that we account for and are accountable to the diverse ways in which they come to be constituted and enacted:

> Native science is a product of a different creative journey and a different history than that of Western science. Native science is not quantum physics or environmental science, but it has come to similar understandings about the workings of the natural laws through experimentation and participation with the natural world. The groundwork for a fruitful dialogue and exchange of knowledge is being created. (p. 14)

Thus, rather than the mirror metaphor of sameness and its constitutive other of difference as oppositional negation, we can consider the ways in which WMS, TEK, and IWLN are in ever-shifting, situated, and differential relations. While both may have reached similar destinations when it comes to notions of flux, uncertainty, and co-constitutiveness, Cajete (2000) reminds us that this destination is shaped by “different creative journey[s]” (p. 14) both in terms of where they have come from as well as where they are going. These currently intersecting pathways are differentially produced, and produce ways-of-knowing-in-being differently. Furthermore, such patterns become rich locations for dialogue: points of resonance become an entry point towards what one can learn from the others’ points of divergence.

Where quantum physics is a recent phenomenon in which WMS is irrevocably facing its ontological limits and limitations (see Barad, 2007, 2010; Peat, 2002), Indigenous ways-of-knowing-in-being have been developed, practiced and honoured since time immemorial with a built-in ethic of (re)generation and sustainability. Constitutive of these ways-of-knowing, and also another difference that matters, is the relationship to spirituality and more-than-human beings:

> Scientists study the tracks of subatomic particles that exist only a millionth of a second. They find the human observer influences the energy relationships and even the nature of existence of these subatomic particles. Humans do participate with everything else even at this level of natural reality. Indigenous people understood this relationship of human activity as concentric rings that extend into the spirit realm. (Cajete, 1994, p. 55)

Within Indigenous ways-of-knowing-in-being, spiritualties cannot be disentangled from co-constitutive epistemologies and ontologies: “it is no accident that learning and teaching unfolded in the context of spirituality in practically every aspect of traditional American Indian [Indigenous]
education” (Cajete, 1994, p. 41). Given Western modernity’s ongoing and complex relationship with religion, spirituality often becomes a contested and complicated cultural interface that can result in the dialectic negation of Indigeneity (see Apffel-Marglin, 2011; Carter, 2004; Marker, 2006). While it is beyond the scope of this chapter, an ethic of dialogue might invite consideration of these patterns of difference that shape this interfacing (for example, Western modernity’s relationship to, and conflating of religion and spirituality; see Apffel-Marglin, 2011).

6.5 Science Pedagogy and Response-Ability: Using and Troubling Vision

If our goal is agential literacy – knowing how to intra-act responsibly within the world – then we must all share the responsibility for preparing future generations to meet the challenges that lie ahead. Agential literacy cannot be taught in one course or even within one curriculum. It is a responsibility that cuts across disciplinary boundaries in the academy and beyond. (Barad, 2000, p. 247)

There are many ways to pedagogically enact a curriculum of agential literacy and/or ecologies of relationships. These include, for example, learning through a curriculum of natural-cultural entanglements within Western modern scientific practices (Barad, 2000), posthuman(ist) science fictions (Gough, 2004, 2006), and land-based pedagogy (Aikenhead & Michell, 2011; Barnhardt and Kawagley, 2005; Cajete, 1999).

However, recall that Barad (2010) reminds us that the (re)opening of response-ability occurs “not through the realization of some existing possibility” (p. 265). This does not strictly entail that the work of methodological response-ability is drawing from that which these pedagogies are (not)142 (i.e., oppositional and mutually exclusive difference) as there is no wholly exterior from which to draw. Rather, re(con)figuring topological relational space between inclusion/exclusion, is to rework pedagogies from what they are to what they are (not), drawing from differential articulations of the whole. In turn, Barad’s (2000) suggestions on behalf of accounting for and being accountable to the natural-cultural entanglements that shape problematics and possibilities of past, present, and futures-to-come are of particular significance. As she suggests above, a pedagogy for agential literacy may be never be wholly constituted by or contained within a (conventionally-conceived) curriculum, nor ever wholly fit within a singular disciplinary space. Pedagogical response-ability is always already distributed. Thus, if a pedagogy will always be a partial yet co-constitutive part-of-the-whole, when considering agential literacy as well as ecologies of relationships, it is important to target nodes that are at once necessary yet inadequate. Such work is not successive or secessive to the pedagogies above but rather supplementary and complimentary.

142 In turn, this is not to criticize the important and fruitful work that others are doing. Rather, it is doing the work of critical complementarity that aims to target their collective supplement to enrich a distributive whole.
In this section, I labour the space of response-ability within, against, and beyond the pedagogically central yet taken for granted sense through which science and science education empirically engage with the world (see Haraway, 1997; Peat, 2002): vision. I do this specifically by targeting photovoice as a pedagogical approach that is already used within science education that relies explicitly on vision (e.g., Cook and Buck, 2010; Cook & Quigley, 2013; Quigley, Dogbey, Che, & Hallo, 2015; Quigley, Dogbey, Che, Hallo, & Womac, 2014). Before the work of **response-ability**, I explore the productive potential of labouring vision and visual pedagogies in the upcoming section (Vision and/in decolonizing science education pedagogy). Within the section following (Response-ability as ongoing rupturing), I locate the nodes in which photovoice demonstrates conceptual ambiguity in order to (re)open its pedagogical structure to new meanings. Following this, I engage twice in doing the double(d) work of response-ability as the iterative reworking of im/possibility and as the cross-cutting of topological reconfiguring by (mis)reading the theories which come to constitute photovoice. Both times, I do so by first substituting Western contemporary analogues of these theories (i.e., feminist standpoint theory and praxis, respectively), followed by Indigenous conceptions of these theories. Insights from these translations and substitutions are then leveraged to differentially constitute photovoice and differential considerations for pedagogy in science education are offered.

### 6.5.1 Vision and/in decolonizing science education pedagogy

Herein, I target vision while simultaneously working towards, as Cajete (1994) defines it, “education [as] an art of process, participation, and making connection” (p. 23). The centering of vision in pedagogy is both significant and productive for a variety of reasons. First, visual pedagogies (i.e., pedagogies centered on the production and reading of visual cultural texts such as photography, video) lend themselves well to working within and against science education, specifically those enactments with decolonizing goals in mind (see Higgins, 2014a, 2014b). As Battiste, Bell, Findlay, Findlay, and Henderson (2005) state, a “Eurocentric curriculum is hidden in plain view” with/in a spectrum of educational institutions as they are often “founded on a vision and visualization of education and culture that look to Europe as the center of all knowledge and civilization” (p. 8). Furthermore, because visuality is the primary and centered sensory medium through which not only WMS operates but also Western modern society in general (see Peat, 2002; Pink, 2006; Rose, 2007), it becomes a critical location to work within, against, and beyond. This is
especially the case since vision is often use as a tool of Western modernity to define itself against its otherness in an oppositional manner:

It was believed that for civilized Europeans the “higher” senses of sight and hearing were most important, in contrast associating the “lower” senses of taste, touch, and smell with animality... [as well as] “primitive” peoples [who] would show a predilection for the “lower” or “animal.” (Pink, 2006, p. 5)

The importance of shifting the gaze from vision (i.e., goals) to visualization (i.e., ways-of-seeing) cannot be understated, not only because visual literacy is increasingly becoming the dominant and most developed form of literacy (note: for those for whom sight is an ability and privilege), but also because of the ways in which who and what is seen, as well as how and where sight is regulated, reinforce dominant ways-of-knowing and ways-of-being while diminishing and denying the validity of others. Given “the plurality, hybridity, and ambiguity of visual practices,” that visual pedagogies provide, a productive critical and complicit location “for unpacking old and new colonialisms” (Battiste et al., 2005, p. 9) is revealed; the self is (re)opened to practices of im/modest witnessing which are sensory, porously subjective, relational, and political while still being rational and “objective”. This also includes recognizing the ways in which Cartesianism comes to shape the field of vision. Here, working within and against Cartesian separation and seperability can take the form of addressing the notion that “what often appear as separate entities (separate sets of concerns) with sharp edges do not actually entail a relation of absolute exteriority at all” (Barad, 2007, p. 135) but rather are always already in relations of mutual and material-discursive co-constitution.

Secondly, visual methodologies are ripe for the work of response-ability towards agential literacy and ecologies of relationships as they are often (already) conceptualized as processual, relational, and interdisciplinary (see Pink, 2006, 2007; Pauwels, 2011; Prosser, 2011). First, the work of visual methodology is always already processual. While it is “common sense” that producing a visual product (e.g., photograph, video) is a process, the pedagogical using can be considered such as well. Because visual products themselves fail to achieve representational sameness through unity of signified and signifier (e.g., a picture is (not) the thing pictured; see Derrida, 2010), the reading of a visual is always an enactment that is contingent, contextual, and multiplicity (O Donoghue, 2011; Pauwels, 2008, 2011). With respect to the work of response-ability, Butler’s (2010) work comes to

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143 This is not to signal objectivity in the conventional sense (i.e., essential qualities that are universal, transcendental, and pre-existing) but rather a re(con)figured objectivity that “is a matter of accountability for what materializes, for what comes to be” (Barad, 2007, p. 361; see also Kirby, 2011); to be accountable to all my relations (see Cajete, 1994, 2000).
bear on the framing that is enacted in (re)producing norms of inclusion/exclusion in both the taking and using of visuals:

The frame does not simply exhibit reality, but actively participates in a strategy of containment, selectively producing and enforcing what will count as reality... Although framing cannot contain what it seeks to make visible or readable, it remains structured by the aim of instrumentalizing certain versions of reality. This means that the frame is always throwing something away, always keeping something out, always de-realizing and de-legitimating alternative versions of reality, discarded negatives of the official version (p. xiii)

Framing, in the production of meanings with visuals (be it during taking or using), (re)produce the very conditions of response-ability: what can be can known, what cannot, and what can the enactment of responsibility can be in turn (see also Barad, 2010; Lather, 2007; Kuokkanen, 2007; Spivak, 1993/2009, 1994). However, because they do not pre-exist visual meaning-making, Butler (2010) reminds that they are always already open to be subverted and differentially enacted through processes of non-reflective reflexivity:

To frame the frame seems to involve a certain highly reflexive overlay of the visual field, but, in my view, this does not have to result in rarified forms of reflexivity. On the contrary, to call the frame into question is to show that the frame never quite contained the scene it was meant to limn, that something was already outside, what made the very sense of the inside possible, recognizable. The frame never quite determined precisely what it is we see, think, recognize, and apprehend. Something exceeds the frame that troubles our sense of reality; in other words, something occurs that does not conform to our established understanding of things. (p. 9)

As Butler (2010) states above, because the frame itself is always ruptured and rupturable (i.e., rather than inaccurate or misplaced), it resists “rarified forms of reflexivity” that require the frame (and the framing self) to be self-same and stable. However, as Butler (2010) suggests, because the frame is always exceeded, there is always the possibility for that which does not conform within to come-to-bear onto the ways in which we frame and are framed. Visual methodologies are, in turn, always relational - a relation to that which is included within the frame as well its constitutive exteriority that is multiplicity and always on the move. As the enactments of taking and using visuals are contingent and contextual, there are various natural-cultural forces and flows which come to bear onto meaning-making: participatory methods explicitly work towards a community of knowers (e.g., Lutrell, 2010; Wang & Burris, 1997); visual production tacitly requires and is only possible due to the (sometimes implicit) participation from the subject of visual production both human and other-than-human (see Pink, 2007); meanings made with visuals are differentially produced given the epistemological, ontological, and ethical relations which come to frame meanings made (see Butler, 2010; Derrida, 2010; Hultman & Lenz-Taguchi, 2010). This resonates with agential literacy: taking and using visuals are not akin to epistemological indeterminacy, but rather co-constitutive onto-
epistemological complimentarity (see Derrida, 2010; Barad, 2007, 2011). Lastly, the processes and products of visual research refuse to fit wholly within a discipline, much less a research paradigm144; they are, by necessity, interdisciplinary. It is often the case that visual research can be found within and across qualitative, arts-based, quisitive, quantitative, and post-qualitative research paradigms (Goldman, 2004; Hultman & Lenz-Taguchi, 2010; O Donoghue, 2011; Pink, 2007). This, in part, has to do with the excessive nature of visuality; it serves as a rich curricular text that always already fails to fit the diverse frameworks we have at our disposal, acting as a productive irritation that invites pedagogically responding to the otherness of the visual text (Derrida, 2010).

6.5.2 Response-ability as ongoing rupturing: Working with/in what photovoice is (not).

While there are many participatory visual methodologies, I decided to methodologically work within, against, and beyond photovoice to develop a pedagogy for teaching a curriculum of ecologies of relationships and agential literacy. In a nutshell, photovoice “is a process by which people can identify, represent, and enhance their community through specific photographic technique” (Wang & Burris, 1997, p. 369) to enhance agency participants already exhibit by visually amplifying their voices around personal and community concerns, experiences and other matters important to them. In a meta-analysis of a large body of literature on photovoice, Hergenrather, Rhodes, Cowan, Bardhoshi, and Pula (2009) demonstrate that photovoice lends itself to the pursuit and realization of a wide variety of community-determined goals (e.g., physical, mental, and emotional health, as well as community development). Given its methodological flexibility, there is not a singular way to practice photovoice; however, photovoice-based projects often follow a step-by-step process (see Table 1). As a methodology, photovoice is often lauded for its potential to empower participants by paving paths for policy change, resisting stereotypical representations that currently frame them in society, and widening the space for other sorts of counter-narratives through “giving voice” (Lutrell, 2010; Mitchell, DeLange, Moletsane, Stuart, & Buthelezi, 2005; Packard, 2008; Pink, 2007; Strack, Magill, & McDonagh, 2005; Wang, 2000, 2006; Wang & Burris, 1994, 1997). Furthermore, photovoice potentially frames a relation that is reciprocally beneficial (i.e. to both participants and researchers), as well as one that can hold deep educational and pedagogical

144 Despite the recent creation and maintenance of visual research as a field onto itself (see Pink, 2007), vision remains excessive. The frames available in in inter-disciplinary explorations do not (yet) allow for the theorizing and practicing of vision (and visual analysis) as at once: sociological (e.g., visual semiotics), aesthetic and affective, biological and optical (e.g., science of sight), technological (e.g., visualization), conceptual (e.g., vision as metaphor), and deconstructive (e.g., photography as spectral, Derrida, 2010).
value for all parties involved (Cook & Buck, 2010; Meyer & Kroeger, 2005; Schell, Ferguson, Hamoline, Shea, & Thomas-Maclean, 2009).

Table 6-1 Photovoice Process (from Hergenrather et al., 2009, p. 695)\textsuperscript{145}

<table>
<thead>
<tr>
<th>Photovoice Process</th>
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<tbody>
<tr>
<td>1. Identification of community issue</td>
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<tr>
<td>2. Participant recruitment</td>
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<tr>
<td>3. Photovoice training</td>
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<tr>
<td>4. Camera distribution and instruction</td>
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<tr>
<td>5. Indentification of photo assignments</td>
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<tr>
<td>6. Photo assignments discussion</td>
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<tr>
<td>7. Data analysis</td>
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<tr>
<td>8. Identification of influential advocates</td>
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<tr>
<td>9. Presentation of photovoice findings</td>
</tr>
<tr>
<td>10. Creation of plans of action for change</td>
</tr>
</tbody>
</table>

However, more productive than exploring and outlining what photovoice is what it is (not)\textsuperscript{146}; the multiplicity of co-constitutive relationships that make photovoice a fruitful location to critically inhabit science education. According to Prosser (2011), photovoice is “the most commonly used visual research method[ology]” (p. 484)\textsuperscript{147}. In turn, it should be no surprise that photovoice is already being used and is also the most employed visual research methodology within science education\textsuperscript{148}. In particular, photovoice is primarily used in science education to pedagogically inflect the exploration of socio-scientific issues with a wide range of learners (e.g., Cook & Buck, 2010; Cook & Quigley, 2013; Quigley et al., 2014). Particularly, Cook and Buck (2010) argue that photovoice lends itself to questions of coming-to-know natural surroundings, as well the entangled socio-cultural implications: how our knowledge is produced (i.e., ‘nature of science’) as well as what

\textsuperscript{145} Reproduced with permission from PNG Publications.

\textsuperscript{146} Recall, from Chapter 3, that is (not) signals using and troubling what is by differentially using the concepts, constructs, and categories available by (mis)reading them through substituting similar but different iterations of the structure under erasure.

\textsuperscript{147} Altering the quotation to signal methodology rather than method is significant. Method, as practice, is inseparable from and entangled with theory and ethics (e.g., Barad, 2007; Lenz-Taguchi, 2010); in turn, method often comes to signal a practice whose theoretical and ethical commitments are absent presences who are taken-for-granted.

\textsuperscript{148} In the Spring of 2016, doing a quick Google Scholar web-search using “science education” paired with a variety of participatory visual research approaches reveals few relevant results as for many participatory visual approaches (e.g., participatory video). However, of these, photovoice is that once which returns the most hits.
this knowledge produces (e.g., environmental issues). Part of the reason why photovoice has become the “most influential and abused methodological genre in visual research” (Prosser, 2011, p. 484) is due to, like scientific literacy earlier, it is (re)presented as a methodological concept that is simultaneously indeterminate yet commonsensically potent. Often, the commonsensical reading of photovoice is one in which a participant-driven photograph is the voice; partnered with the commonsensical critical goals of “giving voice” to “authentic” participants by “speaking for themselves”. Furthermore, photovoice’s success can also be attributed to its providing of a low-entry point into participatory visual research methods (e.g., step-by-step methods; photography as easy-to-procure technology, easy-to-use for participants, and easy-to-disseminate for researchers). While the broad (mis)use of photovoice cannot be disentangled from the conceptual ambiguity that photovoice presents, within the space of response-ability such indeterminacy presents itself as a gift.

Furthermore, photovoice’s reliance on stable cultural meanings and a priori natural bodies were at odds with an attempt to account for, and be accountable to, the complex and contingent flux of culture, nature, and the space between that occurs in the processes of coming-to-know nature (see Barad, 2000, 2010). In short, photovoice is often articulated and enacted as a product and a (re)producer of the metaphysics of individualism that is worked within, against, and beyond in this dissertation (for Indigenous science to-come). In addition, as Castleden and Garvin in their work with the Huu-ay-aht First Nation (2008) caution, “the ‘classic’ photovoice is similar to the academic trend of doing ‘parachute’ research” (p. 1401) when conducted with Indigenous peoples,

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149 Sontag (1977) firmly addresses this by stating that photography is not knowledge at a bargain price (see also Butler, 2010; Derrida, 2010; Meyer & Kroger, 2005). Photographic representation is not so simply mirrored correspondence: “Derrida’s interrogation of photography works to open the medium to its own alterity, to the ways in which photography exposes the non-self-identity and internal self-differentiation that, for him, ultimately condition any act of aesthetic experience and its ethicopolitical futurity” (Richter, 2010, p. xxi). Articulated otherwise, the is-ness of the photograph is always on the move as a space-time referent that will never come to be again is brought into a differentially situated present in which meaning is made, (re)producing it otherwise. It is for this reason that for Derrida (2010), the spectral is at the heart of photography; it never achieves mirror-able ontological stability, but rather is visited by hauntological indeterminacy.

150 For Spivak (1988a), the academy is often guilty of conflating two related but incongruous meanings of “representation”: political representation (i.e., speaking for) and re-presentation (i.e., speaking about, presenting again). When voices are presented as “authentic” or that they could “speak for themselves” in the context of political representation, the representational act and its complicities therein are obscured. This plays out through a variety of mechanisms: a) the representer is naturalized and made “neutral” through their non-representation; b) the represented are (re-)constructed as deficient through both the need of an academic “ventriloquist” and re-centering the academy as “those who know;” c) the unexamined representer-represented relationship reifies the unexamined and deeply problematic norms through which the voice was produced both during the fieldwork (i.e., the panoptic act of research participation) and in the textual production (i.e., representation). In turn, she suggests that representation is always already an encounter that is an imperial act of epistemic violence whose complexities and complicities should not be so easily side-stepped by having participants “speak for themselves” (see also Lather, 2007; Spivak, 1993/2009).
knowledges, practices, and/or places if photovoice’s (oft-implicit) cultural enactments are not addressed. Accordingly, the established conception of photovoice itself would require a methodological (re)opening not only because it is productive, but also because it is necessary for Indigenous science to-come.

Like any and every methodology, there are multiple self-trangressive moments in which photovoice both encompasses and eschews itself which provide important locations to work within and against\(^{151}\). However, photovoice’s space of indeterminacy that I engage with through the ongoing rupturing of response-ability in this chapter is the differing and deferring space between what photovoice theoretically \textit{is} and \textit{is (not)}. Critically inhabiting this space offers rich possibilities for disrupting, displacing and differentially enacting photovoice for two distinct yet interconnected reasons\(^{152}\). First, within the context of photovoice, theory presents itself as a signifier whose signified is unstable and undecidable. Where methodology is the interconnected space between theory, practice and ethics, most efforts towards reworking photovoice often centre research practices and ethics (e.g., Lutrell, 2010; Papademas, 2004). Accordingly, the theories that frame photovoice are often defined and deployed in a cursory and rapid manner: photovoice is occasionally presented as a \textit{method} in turn. While praxis and feminist standpoint theory are gestured to and enacted within most but not all photovoice-based projects (i.e., theory is always already entangled with/in practice; see Barad, 2007; Lenz-Taguchi, 2010), it is not always clear as to which iteration of these theories is being referred to. Rather, the meaning always differs and is deferred\(^{153}\) (see Derrida, 1976). As such, photovoice’s theoretical framings often present themselves as very suitable sites for

\(^{151}\) For example, the plugging in of voice into photography or vice versa implied by the name photovoice is but one example of the ways in which the frames that shape photovoice as a methodology are always already being ruptured and are self-rupturing:

How can photographs be thought of as having, or be said to have, voices? Or are we referring to the verbalizations that are made and/or voices that are heard alongside/about photographs? Is there a sense that visual voices are doing what verbal ones cannot? How much do visual voices need verbal ones? (Lutrell & Chalfen, 2010, p. 199).

\(^{152}\) Recall from Chapter 1 (i.e., the introduction) that deconstruction is a two-part process which entails locating a snag in the structure (i.e., a moment of undecidable signification which threatens the structure), and then using the lever of the signifier (e.g., (mis)reading an unintended signified) to pry open the structure to allow for (re)signification which displaces the structure (Derrida, 1976; Spivak, 1976).

\(^{153}\) It is becoming increasingly common to see cursory descriptions such as the following: “photovoice is a participatory action research (PAR) method based on … the theoretical literature on education for critical consciousness [i.e. Freire’s critical pedagogy], feminist theory, and a community-based approach to documentary photography” (Wang, 2006, p. 148). These definitions are usually accompanied by a citation which defers meaning to an “originary” conception of photovoice (e.g. Wang & Burris, 1994, 1997). However, because these theories are only given a somewhat longer but still rapid defining, meaning always differs from one text to another across different authors. This is especially the case for the signer “feminist theory”. Because it is a term that always already invites multiple differential readings (i.e. there are multiple signified \textit{feminist theories} which could be read through this signifier), we see this term becomes otherwise as other researchers take it up. For example, it becomes “feminist research theory” (Strack et al., 2005) and “feminist action research” (Meyer & Kroeger, 2005).
productive (mis)readings and substitutions of differential and unintended understanding of praxis and feminist standpoint theory. Second, the widening space between what photovoice theoretically is and is (not) offers itself as a long, and ever-lengthening lever to pry this space open while maintaining a critical inhabitation of this methodology. To elaborate, there is a widening and disruptive disjuncture between the ever-expanding fields of praxis and feminist standpoint theory and the particular temporal and cultural iterations of these theories that usually shape photovoice. What photovoice theoretically is does not fully reflect the shifts, breaks and developments within these respective fields, be they theoretical framings or practical applications. However, the differentiation between what photovoice theoretically is (e.g., Freirian praxis) and is (not) (e.g., Lather’s praxis 2.0 or Indigenous praxis) does not reject the structure (e.g., praxis) provides the necessary leverage to pry open the structure of photovoice. In turn, prying open (i.e., (mis)reading) with what photovoice theoretically is (not) allows for a working within and against photovoice that does not jettison the theories that constitute it but rather considers similar yet different understandings thereof.

Like with scientific literacy earlier, I aim to enact a cross-cutting of the topological space of response-ability and iteratively rework im/possibility by (mis)reading in two sequential rounds which move us from within and against to something that is within and beyond. Here, I begin by substituting both feminist standpoint theory and praxis with more contemporary analogous theories that have turned the critical gaze inwards. This is succeeded the substitution of Indigenous conceptions of similar theories (i.e., praxis and feminist standpoint theory -> Indigenous praxis and Indigenous standpoint theory) to think photovoice otherwise: towards teaching and learning with/in ecologies of relationships.

6.5.3 Response-ability as the iterative reworking of im/possibility and as cross-cutting of topological re(con)figuring: (Mis)reading standpoint.

Photovoice strongly draws upon conceptions of feminist standpoint theories in order to frame participants’ perspectives and perspectivities. The central premise of feminist standpoint theory is that experience is an epistemic privilege with respect to questions of knowledge production about one’s one self-situatedness. This assumes that members of a community are already well situated to explore their own issues and priorities (Harding, 2009; Pohlhaus, 2002). In early conceptions of

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154 For readers interested in a more exhaustive treatment of the theoretical reworking photovoice vis-à-vis what it theoretically is (not), this is taken up elsewhere (Higgins, 2014, 2016b).
standpoint theory that have been widely taken up by photovoice, a standpoint is often theorized as something that is singular and that one always already has, rather than pluralistic and forged.

One of the methodological locations in which feminist standpoint theory informs photovoice-based research is during the participant photograph-generation process (occurring between step 5 and 6 in Table 1). During this phase of the process, participants go about their day-to-day lives paying attention for moments, spaces and places that might signify the earlier agreed-upon guiding questions such as *what are the challenges that we face as and within our community?* When significant for a participant, they utilize their disposable camera to visually articulate a response to the question. The working assumption here is that when participants are addressing the question via a picture, they are doing so from their *possessive* and *singular* standpoint (which pre-exists meaning-making)\(^{155}\).

### 6.5.3.1 Response-ability as the iterative reworking of im/possibility: (Mis)reading standpoint as standpoints.

The continued labouring of standpoint by feminist standpoint theorists provides several inroads to consider how standpoints emerges as complex, nuanced, and multiplicity. Feminist standpoints – plural – recognize that standpoints: a) emerge through societal structures; b) emerge from, but are not equivalent to, everyday lives; and c) are not inherent or acquired, rather, they are forged with and in an emergent community of knowers (Harding 2009; Pohlhaus 2002).

To rework the topological space by (mis)reading standpoint as standpoints within photovoice involves working with a conception of knowing *with* one another, as a complex and complicated inter-subjective labour, rather than simply knowing. This presents a deep challenge to photovoice’s oft-cited goal of visually “giving voice”. In particular, it troubles the notion that a participant’s voice sits idle, separate, and static waiting for a researcher to act as megaphone. Rather, the voice stemming from standpoints are always already the result of inter-subjective knowledge production. To substitute standpoints might differentially produce photovoice as a methodology that (impossibly) accounts for the inter-subjective norms of what counts as knowledge, as well as the mechanisms for producing, recognizing, and justifying knowledge within and beyond the relationships of a particular community of knowers. Whether ignored, concealed, or made explicit, photovoice always already emerges from the standpoint of a community of knowers. In turn, such a

\(^{155}\) When standpoint is at once presented as singular and something one already has rather than collective, emergent, shifting and complex, it becomes synonymous with an all-too-simple stable and problematic conception of identity as the (mirrored) sum of one’s markers of identity.
photovoice is never given, static, or individualistic in nature.

Such a reworking is significant for science education where ‘what counts’ as scientific knowledge continues to be contested. It potentially produces a space to explore coming-to-know nature as a process that also considers the immediate and explicit knowledge navigations and negotiations within a classroom by treating it as a community of knowers (e.g., when discussing and negotiation knowledge claims around participant-driven photographs of ‘nature’). Further, it produces a space to consider the inclusion those who are implicitly inter-subjectively included in knowledge production (e.g., scientists, through normative discourse around knowing nature) and those who will come-to-know with the community of knowers (e.g., policy-makers, in relation to eco-social issues). These negotiations, relationships, and modes, through which knowledge are produced are as important, whether implicit or explicit, as the knowledge itself.

6.5.3.2 **Response-ability as cross-cutting of topological re(con)figuring: (Mis)reading standpoint as Indigenous standpoint.**

Drawing from and building upon feminist scholars’ work on standpoint theory, Torres Strait Islander scholar Martin Nakata developed a model of inquiry which begins its investigation from the cultural interface (i.e., the complex and contradictory space where Western (modern-ist) and Indigenous thought intersect and overlap): an Indigenous standpoint theory (Nakata, 2007a, Nakata, 2007b). Here, “people’s lived experience at the cultural interface is the point of entry for investigation, not the case under investigation” (Nakata, 2007b, p. 12). Differentially echoing the aforementioned ongoing labour of standpoint(s), forging a standpoint at the cultural interface does not simply take experience as ready-made knowledge, but rather engages with the questions that can be asked from these experiences through critical reflexivity on both the self (via experience) and the self-in-relation (via structural and social relations)\(^\text{156}\). Furthermore, Nakata (2007a, 2007b) offers three principles he considers useful for understanding, investigating and developing a position: a) the

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\(^{156}\) For Nakata (2007a), Indigenous standpoint theory is:

\[\text{a method of inquiry, a process for making more intelligible ‘the corpus of objectified knowledge about us [Indigenous peoples]’ as it emerges and organizes understanding of our lived realities. [It is] theorizing knowledge from a particular and interested position — not to produce the ‘truth’ of the Indigenous position but to better reveal the workings of knowledge and how understanding of Indigenous people is caught up and implicated in its work. (p. 215)}\]

McGloin (2009) adds the rejoinder that the labouring of a standpoint vis-à-vis the cultural interface is a task that befits not only Indigenous peoples as the tensions at the interface affect each and everyone one of us, albeit differentially. Particularly, she states that for Western academics, forging a standpoint by engaging the work of critically engaging with/in the ways in which the self at the cultural interface is produced and produceable allows for the possibility of differently inhabiting this Indigenous-Western interface that is often characterized by a unidirectional dialectic negation.
first principle is that the cultural interface is a contested knowledge space; b) the second principle offered is that agency is framed by the cultural interface; and, c) the third principle offered is that the tensions at the cultural interface are embodied experiences.

By (mis)reading standpoint theory as Indigenous standpoint theory within the context of photovoice, and extending the previous production of (mis)reading standpoints, we can come to consider the ways in which the voice in photovoice produced and produceable at the cultural interface. Particularly, we are invited to consider the ways in which Indigenous knowledges are “textually” received at the cultural interface by also critically and complicity including its potential “readers,” intended and unintended, are co-constitutive of the community of knowers through which a voice emerges (i.e., processes of dissemination and (re)presentation in which what is read is not mirrored representation but rather diffractive production). Considering the voice of photovoice emerging at the cultural interface requires a consideration of the dialectic negation that often occurs here: particularly colonizing tendencies to treat Indigenous peoples and knowledges in a double(d) problematic and polarizing manner. In turn, it is important to utilize a (re)presentation strategy which works to keep meaning on the move (i.e., not sedimenting within problematic poles) which also creates the possibility for a reader to be(come) aware of their own agency with/in the distributed whole that is meaning-making with photovoice. Like with other practices that work to resist the common colonizing closure of the cultural interface (e.g., Indigenous Métissage [Donald, 2011], poetic transcription of Indigenous voices and knowledges [Madden, Higgins, & Korteweg, 2013]), I deploy representational indeterminacy and inter-textuality through juxtaposition as a practice that potentially interrupts and allows for readers to be partially cognizant of the ways in which too simple readings are already sutured over by colonial imaginaries (i.e., potentially (re)opening the space of response-ability). Photographic and textual juxtaposition here works by requiring a substantially active engagement from a reader as meaning resides not only with/in the text (re)presented but also in-between the “textual” elements read: the “common sense” imaginary of the text as representational mirror is ruptured as the meaning made emerges between the multiplicity that is the reader and the text. However, while such juxtaposition presents analytic and representational

157 Indigenous peoples and knowledges are often asked to align with either Western or an Indigenous position, the latter being read as a pan-Indigenous position of the past to either be romanticized or pathologized. These colonizing frames problematically (re)produce Indigenous peoples and knowledges as uniform and ‘knowable’, as well as separate from and inferior to their Western counterparts (Donald, 2011; Higgins et al., 2015; Nakata, 2007a, 2007b). Furthermore, as this is largely a process of suturing over with colonial imaginaries and through a metaphysics of individualism, the space of response-ability towards the complexities and contradictions which occur at the cultural interface.
opportunities to momentarily interrupt reading practices sutured over by colonial imaginaries, it does so with purpose but not with guarantee.

Such (re)consideration of photovoice with Indigenous standpoint theory is of great significance for its use in a science education pedagogy for agential literacy and ecologies of relationships as it extends the notion of inter-subjectivity to consider the space of response-ability. Particularly, it asks us to consider responsibility towards the possible possibilities of how IWLN and TEK might be read alongside WMS – especially considering the ways in which that relationship is characterized by dialectic negation. In turn, the use of juxtaposition as (re)presentational strategy aids in the disruption of a metaphysical mirror of correspondence (see Chapter 3) and helps us work towards something more closely akin to co-constitutive relationships amongst non-self-same elements: creating condition in which meanings necessitate an in-between-ness requires (and invites non-reflective self-reflexivity onto) process and flow.

6.5.4 Response-ability as the iterative reworking of im/possibility and as cross-cutting of topological re(con)figuring: (Mis)reading praxis.

Typically within photovoice, Paulo Freire’s (1970/2000) conception of praxis guides an understanding that research participants need to be active agents in both coming-to-understand and transforming their own limiting situations through the collective linking of critical theory and practice. Freire (1970/2000) outlines the role of the researcher/pedagogue as one of assisting or aiding the “oppressed” in becoming aware of their personal “limit situations”, to imagine themselves beyond these “limits” and to act accordingly in order to ultimately overcome their own oppression. When the cycle of reflection and action is one that is forged with, rather than imposed on, those who are on the path of conscientization, praxis holds promise of emancipation.

One of the locations in which praxis informs the photovoice process is through the process of collective critical reflection upon participant generated photographs (see step 6 in Table 1). During this process, participants talk about one or more pictures that they feel are significant in relation to the agreed-upon community issue or problem determined at an earlier point in time, or one they “simply like best” (Wang, 2006, p. 161). Following this, participants collectively take a critical stance with respect to that which is presented within the photographs used by engaging with the questions contained within the mnemonic SHOWeD: “What do you See here? What’s really Happening here? How does this relate to Our lives? Why does this situation, concern, or strength exist? What can we Do about it?” (Wang, 2006, p. 161). After responding to these questions,
participants collectively boil down the critical content through thematic coding, with the help of a researcher. Thus, photovoice often frames participants’ pathway to conscientization and very possibility of empowerment as the ability to articulate personal and community issues and problematics in the clear, concise, yet reductionistic language of policy.

6.5.4.1 Response-ability as the iterative reworking of im/possibility: (Mis)reading praxis as praxis 2.0.

It has often been argued that the application of Freirian praxis by scholars who occupy dominant positions and perspectives has been far from ‘emancipatory’ (Ellsworth, 1989; Lather, 1986, 2007). This produced generative friction that gave birth to what Lather (1986, 2007) refers to as praxis 2.0. In short, praxis 2.0 is a vigilant and ongoing critical engagement with the ways in which research reifies the problems that is seeks to address, as well as the ways in which researchers come to be subjects through those same norms (see also Ellsworth, 1989).

To (mis)read praxis by substituting praxis 2.0 within photovoice invites consideration of the approach’s goals of empowerment within the (deconstructive) space of dis/empowerment. It is a call for critical and complicit engagement with/in the space that recognizes the ways in which research and researchers are contributing simultaneously to both the problem and the solution. There is an ongoing need to critically assess and work against the ways in which conceptions of empowerment produce disempowerment in practice, as well as the ways in which both participants and researchers are produced and produceable within societal norms. A practice this might entail is the double(d) reversal of the ethnographic gaze (see Chapter 5). This entails both the literal reversal to examine those who do the studying (i.e., to reverse the direction of the gaze), as well as analysis of the ways in which those who do the studying study (i.e., to reverse the produceability of the gaze). This entails an ever-partial non-reflective self-reflexive accounting for, and (un)doing of the process of becoming, researching subjects (e.g., participating in the production of dis/empowerment; see Pillow, 2003; Lather, 2007).

Such a self-reflexive apparatus has purpose and purview within science education, whereby the normative position(ality) of science educator works against accounting for and being accountable to the flux of culture and nature involved in meaning-making processes with nature as well as how these produce and make produceable the ‘self’ of science education. This becomes all the more productive when considering the ways in which WMS, which largely shapes science education and educator, dialectically negates other ways-of-knowing nature (see Higgins 2014a). Also, as explored
earlier within this dissertation (e.g., Chapters 4 and 5), such subsuming, sublating, and suturing over
can even occur when one desires it to be otherwise through the ways in which “common sense”
makes itself common: (re)shaping science curriculum and pedagogy, teacher and learner. In turn, a
double(d) reversal of the gaze might allow for new meanings of critical science education, educator,
and researcher to take hold.

6.5.4.2 Response-ability as the cross-cutting of topological re(con)figuring: (Mis)reading praxis as Indigenous praxis.

While understandings of praxis have since differentially proliferated, here it is useful to consider the critical action that is linked to the interfaced space between Western critical theory and Indigenous philosophy (i.e., an Indigenous praxis). Of particular note is Grande’s (2004, 2008) Red Pedagogy, which begins with recognition of the many ways that (Western) critical theories do not always overlap with Indigenous philosophies. By placing the core assumptions and constructs of praxis under a critical Indigenous gaze, Grande comes to the conclusion that if the conventional project of praxis does not also include a co-occurring analysis of (neo-)colonialism, research risks reproducing and upholding power structures that negatively impact Indigenous peoples, places, and practices through the (re)production of (neo-)colonial structures (see also Smith, 1999/2012, 2005).

To (mis)read praxis as Indigenous praxis when (re)constituting photovoice invites a continued (re)consideration of the ways in which empowerment is framed. Particularly, thinking with Indigenous praxis invites us to differentially enact the concepts of freedom and autonomy that are sought after as the ends that justify the means of praxis. Conventionally, freedom and autonomy are framed within spaces of egalitarian and individualistic democracy that fail to recognize the ways in which they might be framed within an Indigenous ecology of relationships. Notably, Indigenous praxis reminds that land is not simply property to be equally redistributed but rather part of the co-constitutive whole that also comes to shape the individual who is to be “empowered.” In turn, the other-than-humans (e.g., plants, rivers) and more-than-humans (e.g., spiritual beings) which co-constitute place should not only be included for political reasons (e.g., land claims), but also because they are active, important, and oft-neglected members of the ecologies of relationships that shape the cultural interface. This invites a shift from an anthropocentric view of land (e.g., nature as inert, acultural, and exists for humans to exploit) towards one in which humans are responsible for, nurtured by, and thus intimately connected to land (Cajete, 1994, 1999, 2000; see also Chapter 5). In turn, a reconfigured notion of photovoice via Indigenous conceptions of praxis invites us to consider
voice not only as individualistic, and only possible through human agency, but also stemming from and with/in a place-based community that includes humans, other-than-humans, and more-than-humans. Furthermore, it is an invitation to consider (photo)voice not as a singular (photo)voice speaking about an ecology of relationships but rather one speaking with it enfolds it within: the part (i.e., the photovoice) is a first person plural that is a differential production of the whole (i.e., the human, other-than-human, and more-than-human relations with/in which this voice emerged).

This is significant within science education wherein, as explored within the previous curricular section, to be scientifically literate largely becomes a function of being able to “read” nature (and others’ accounts of nature). However, to know with nature rather than about as a pedagogical framing (re)opens the space of response-ability for both educators and students, albeit a potentiality that is not always actualized.

6.6 Conclusion: From Designing with Response-Ability Towards a Pedagogy for/as Indigenous Science To-Come

We move away from Plato’s gift of ontological determination, a logic of identity [i.e., self-sameness] and prediction – science is this; science is not that – toward a logic of the “and” – This and this and this and this… (St. Pierre, 2011a, p. 613, emphasis in original)

The potentiality of deconstructive work lays neither strictly in its ability to identify the constitutive otherness of concepts, categories, and constructs, nor in meaning that inevitably ruptures and shifts what science is and is (not). Rather, the ongoing possibility towards an engaged act of account- and response-ability towards constitutive otherness and an ever-present invitation to re-construct with that was excluded is the key. As we continue moving towards a curricular and pedagogical practice of science education that productively inhabits the cultural interface between WMS and IWLN, it is important to remember that pluralism in science education does not simply imply there are different epistemological means of approaching the same ontological reality to generate similar results. To this, Latour (1993) reminds that some epistemological means are nonetheless positioned as superior to others through particular universalism (some usually being Western modern epistemologies). As St. Pierre (2011a) suggest in the quotation that opens this section, we can move away from Plato’s gift of ontological determination not through negation, but as a coming to recognize it as but one

158 For example, Castleden and Garvin in their work with the Huu-ay-aht First Nation (2008) to address past, present, and future community ‘needs for cedar, a sacred resource’ (p. 1396), adapted photovoice methods by including ‘a feedback loop, seeking input from the entire community at regular intervals throughout the project’ (Castleden et al., 2008, p. 1401). However, what would it have meant for this photovoice project to have been framed as one that is speaking with rather than about cedar?
ontological possibility amongst many. It is for this reason that Barad (2000) claims adaptation of science education is never simply one of “candy coating” the content with relevant material; rather, “questions of relevancy are intertwined with questions of subjectivity and epistemic responsibility” (Barad, 2000, p. 222).

However, responsibility and responsiveness are not enough. Rather, they also require the ability to respond. This insight became the methodological drive herein via the concept of *response-ability* (see Barad, 2010; Kuokkanen, 2007, 2010; Spivak, 1994). Drawing from Barad’s (2010) conception of response-ability, as well as the previous deconstructive approaches in Chapters 2-5, (re)opening the space of response-ability was achieved through three co-constitutive strategies: a) response-ability as ongoing rupturing; b) response-ability as the cross-cutting of topological re(con)figuring; and c) response-ability as the iterative reworking of im/possibility. These three strategies were then leveraged to re(con)figure curriculum and pedagogy around the central yet conceptually ambiguous nodes of *scientific literacy* and *visual pedagogies* respectively.

Identifying scientific literacy’s necessary yet inadequate, prevalent yet ambiguous, status within science education made it a rich curricular location from which to engage in the work of response-ability. As “learning and teaching are occurring at all times, at all levels, and in a variety of situations” (Cajete, 1994, p. 40), science curriculum could be then re(con)figured with/in the relational ways-of-knowing-in-being that co-substantiate it. Agential realism and Indigenous science here provide important insights into the entanglement of knowing and being, as well as how we might imagine them otherwise in the pursuit of knowing nature (i.e., scientific literacy). As this chapter has shown, with/in the points of convergence between Barad’s *agential realism* and Cajete’s *ecologies of relationships* are ways-of-knowing-in-being that are shaped by ethics, accountability, and responsibility to the (re)generation of that which we, as humans, co-constitute and are co-constituted by. This, of course, has great consequences for what scientific literacy *is, is not*, and, perhaps most importantly, *can be*.

Vision, like with scientific literacy above, provided a rich location which is at once central yet taken-for-granted within science education. As such, I targeted a pedagogy that explicitly used the visual as a point of departure: photovoice. Like all methodologies, photovoice is open to re(con)figuration through a differential entanglement of theory, practice, and ethics. Through deconstructive (mis)readings, the absent presence of critical humanist theories entangled with/in photovoice (i.e., standpoint theory and praxis) were misread as, and substituted with, differential
conceptions of these same theories in order to reconceptualize photovoice. From this work four major openings were created. First, this entailed (re)considering photovoice as something that one comes to through communal struggle which accounts for its own inter-subjectivity (e.g., already considering the relations of power in its co-constitutive address) rather than an isolated, singular voice stemming from a singular individual. Second, this involved (re)considering photovoice not only as individualistic and only possible through human agency, but also stemming from a place-based community that includes humans, other-than-humans, and more-than-humans. Third, these deconstructive (mis)readings questioned the possibility of empowerment by positing dis/empowerment and recommended a re(con)figured reflexivity (see Chapter 2’s suspended action and Chapter 5’s reverse anthropology). This would entail a double(d) process that reverses both the ethnographic gaze, as well as its production. Fourth, an invitation to consider visual juxtaposition as a means of working against the epistemic violence that occurs and is made possible by reading practices that do not interrupt, and potentially make readers cognizant of the ways in which too simple readings are already sutured over by colonial imaginaries was offered.

Using these openings, the space of response-ability will be further laboured in the next chapter by dialogically interfacing a re(con)figured sense of scientific literacy with a re(con)figured photovoice. In particular, they will be brought into proximal relation through their entanglement with/in points of resonance with (meta-)fiction, Indigenous storywork, and comic book theory. In turn, this comes to produce a pedagogical approach that centers knowing with nature as a relational and performative act in which the whole (i.e., the ecology of relationships) is enfolded with/in the part (i.e., the story). Such an approach simultaneously works to resist the too-easy reading that it is knowledge about nature. As Barad (2007) suggests, “intra-actions iteratively reconfigure what is possible and what is impossible – possibilities do not sit still” (p. 234). There are always multiple possible possibilities with respect to pedagogies that account for and are accountable to the ecology of relationships one finds oneself in, enacts, and is enacted by. However, as the exclusion of constitutive otherness always comes-to-be, the work of deconstructing and reconstructing (e.g., response-ability) continues to be a recursive and iterative process; this work is never over, nor is it individualistic in nature.
Chapter 7: Visually Storying Relationships to Place and/as Indigenous Science

To-Come: an Open-Ended Conclusion

Any act of reading is besieged and delivered by the precariousness of intertextuality. And translation is, after all, one version of intertextuality… heavy-handedness cannot punctuate an entire text where “penser” (to think) carries within itself and points at “panser” (to dress a wound); for does not thinking seek forever to clamp a dressing over the gaping and violent wound of the impossibility of thought? (Spivak, 1976, p. lxxxvi).

How does one go about “closing” a dissertation whose primary task is to (re)open the metaphysics of clôture (i.e., as double(d) closure [verb] and enclosure [noun])? When “each act of reading the ‘text’ is a preface to the next” (Spivak, 1976, p. xii), a conclusion (as with an introduction; see Chapter 1) must always be open at both ends, provisional, and contingent. Translating text into the context of (a) conclusion does not necessitate its (whole) surrender to the context: a conclusion remains open to (its own) intertextuality, never (fully) achieving closure.

As Spivak (1976) implicitly asks, how could it ever achieve closure? The heavy-handedness of clôture can never fully foreclose the possibility of thought (penser) that confronts from outside the concepts, categories, and constructs that we hold and that hold us. This confrontation always retains the possibility of rupturing the clôture of metaphysics, leaving us wounded by thought (see also Britzmann, 2003; Lather, 2007) and (re)opened by that which is to-come. However, this potential is never fully achieved, “for does not thinking [(i.e., panser)] seek forever to clamp a dressing over the gaping and violent wound of the impossibility of thought” (Spivak, 1976, p. lxxxvi)? In other words, not all thought (re)opens: thought is, at once, both the possibility of thinking anew and thinking again. As poison and panacea, it is nonetheless necessary and unavoidable: “thinking about science is part of doing science” (Barad, 2000, p. 245). Thinking, both penser and panser, are never disentangled from relationships (e.g., Indigenous science) to-come that vacillate between becoming and unbecoming.

As Barad (2012c) states, “ontological indeterminacy, a radical openness, an infinity of possibilities, is at the core of mattering” (p. 16, emphasis mine), of how relationships are (re)generated through the world’s ongoing becoming (see also Apffel-Marglin, 2011; Cajete, 1994, 2000; Little Bear, 2016). Accordingly, Kuokannen (2007) reminds that the violence of/to metaphysical clôture and the ontological indeterminacy (rather than epistemological uncertainty) that comes with it are the necessary conditions for the spirit of the gift to circulate, for new relations to be formed and for relations to be formed anew (see also Apffel-Marglin, 2011). For Kuokannen
(2007), such rupturing is in itself a gift, albeit a difficult one. This dissertation, where Indigenous science is considered to-come, centres the invitation to (re)open the spaces of science education (through a double(d) inversion of the gaze back onto itself) so that science education might be wounded by thought and open(ed) to new and renewed relationships to Indigenous science (to-come).

Thus, the task within this conclusion is not to strive for the “rage for unity” (Spivak, 1976); that is, the tidying up of untimely and disorderly loose ends to achieve the closure typically presumed of concluding. Rather than tuck, trim, and tidy away the partially extended relationalities(-to-come) on which we have journeyed, this chapter is presented as an open-ended conclusion whose possible possibilities also reside in (and beyond) what may have been and what may yet be actualized. Towards this end, the open-ended conclusion explores two parts and processes.

First, I offer a summary and synthesis of the dissertation to highlight the ways in which Indigenous science is to-come. However, as in Chapter 2, I call attention to the notion that this potentiality is not transcendental. Rather, it occurs within relationship, where you – the reader – are entangled (recognizing that the “you” addressed here is subjectively (un)done in material-discursive relations as the language-practices you possess also possess you). You are encouraged to pay attention to the ways in which thought manifested throughout. (How) Did it wound, allowing for the possibility of Indigenous science to-come (i.e., penser)? (How) Did thought work to cover the wound, leaving Indigenous science as yet-to-come (i.e., panser)?

In the second part of the conclusion, I engage with the precarious intertextuality of translation: (mis)translating the practice of post-colonial and decolonizing science education scholarship into a context of school-based teaching and learning. I continue the work of responsibility of the previous chapter, by re(con)figuring concepts of agential literacy, “sense of place,” and differential enactments of photovoice into a new ecology of relationships as means to provoke thought as penser, rather than panser. I explore these potentialities through a partial and contingent account of a month-long curricular collaboration titled Visually Storying Relationships to Place.

7.1 Part 1: Mapping Pathways Travelled Upon and Those To-Come

The central project of this dissertation has been one of allowing for the radical potentiality of
thinking (*penser*) Indigenous science within the context of science education, rather than upholding thinking (*panser*) that, through foreclosure, excludes, differs, and defers Indigenous science. As such, the central question guiding this entire inquiry has been *How is Indigenous science to-come with/in the context of science education?* Recall that this central question is understood and has been explored in through three guiding inflections that are inseparably entangled. First, *to-come* continues to signal that Indigenous science, in the context of science education, has not yet (wholly) arrived. Secondly, *to-come* signals ethical indebtedness: *How might the structure, culture, and discipline of science education be (re)opened and re(con)figured to receive Indigenous science to-come, on its own terms, and in ethical relation?* Thirdly, *to-come* entails a responsibility (and response-ability) for and towards that which is *to-come*: *What types of practices might allow for and nurture the possibility of Indigenous science to-come?*

While Indigenous science is still *to-come* in all three inflections - upon conclusion of this dissertation\(^\text{160}\), I continue to be driven by the goal of exploring what possibilities are made possible through the labour of attempting to be response-able and account-able (see Barad, 2010) to Indigenous metaphysics waiting in the wings. As a means of responding to this guiding question and goal, I *translate* the pathways of science education journeyed upon in each chapter into the format of a rough sketch. These sketches offer a synthesis of Indigenous science to-come in one or more of its inflections, as well as an overview of the chapter contributions to the field of science education. As these sketches are enactments, they are *mappings* that are meant to invite relation as living, breathing concepts rather than (re)tracings who are epistemologically and ontologically foreclosed through representationalism (see Lenz-Taguchi, 2010).

### 7.1.1 Chapter 2: Serious play: A literature review of multicultural science education through and for (Socratic) dialogue.

Wandering through the pathway(s) presented by the multicultural science education debate, the most glaring feature of the scholarly literature strongly conflicting epistemic demands on “what counts” as science (and in turn school-science curricula) and respectful education within multicultural science education classrooms (see Lewis & Aikenhead, 2001; McKinley & Stewart, 2012; van Eijck & Roth, 2007). At stake is the inclusion of TEK and IWLN alongside WMS. This highly contested commitment and practice nearly (wholly) polarizes the field, resulting in two

\(^{160}\) It can be, and has been stated that the possibility for Indigenous science to (wholly) arrive on its own terms and in ethical relation is an impossible possibility in this contemporary moment (see Carter, 2004; McKinley & Aikenhead, 2005).
seemingly diametrically opposed positions. Cross-culturalists advocate for the inclusion of TEK and IWLN on the basis that they are equally (but not similarly) valid; universalists do not consider these placed-based ways-of-knowing nature as equally valid to the “universal” standard of WMS. These positions directly impact conceptions and enactments of respecting and including diverse knowledge traditions that students bring and, in turn, students themselves.

Mapping the contours of the path, the culture of the debate can be said to deploy both dialectic negation (see Bohm, 1996), as well as adversariality (as method; see Moulton, 1983). This regularly brings the potentiality and possibility of creative movement through the field of science education to a viscous stasis, although never achieving a grinding halt. On this note, Southerland (2000) commented early on that the multicultural science education debate was, “generating a lot of heat, but very little light” (Southerland, 2000, p. 289). While the critical task of addressing conflicting values “head on” is a one of necessity and importance, the literature seems to indicate that changes through current modes of engagement have been, and continue to be, slow and partial. This invites an important question that is revisited in many ways throughout the dissertation: How might coming at these issues of metaphysical closure and seemingly sedimented knowledge-practices sideways and obliquely provide new (re)openings?

A central contribution to science education that is produced through this chapter is (re)considering the multicultural science education debate obliquely through its antagonism. While I am not the first and likely will not be the last to consider the antagonistic nature of the multicultural science education debate (e.g., McKinley & Stewart, 2012; van Eijk & Roth, 2007), putting theories, strategies, and practices of conflict resolution to work are notable (e.g., dialogue; see Bohm, 1996). A multiplicity of tools, practices, and considerations are provided for attending to, and reconfiguring, the (re)production of adversariality. These include consideration of meaning-making as relational and embodied (e.g., paying attention to emotions and physical responses as indicators of the movement of thought), as well as seeking out shared meanings as productive pathways and paths of lesser resistance. Examples of shared meanings sought in Chapter 2 include knowledge as knowledge-practice (van Eick & Roth, 2007); and knowledge practices as epistemologically situated (van Eick & Roth, 2007), ontologically situated (Cobern & Loving, 2008), and culturally hybrid (van Eijck & Roth, 2009).

The deconstructive tool put to work within Chapter 2 was the play of (re)signification. As the
first of many deconstructive strategies employed and leveraged throughout this dissertation, the play of (re)signification invites the reader to consider the ways in which textual realism (i.e., representational fidelity; see Carter, 2004) is a cultural myth that diverts and at times disallows the wandering of the pathways of science education otherwise.

7.1.2 Chapter 3: Mirrors, prisms, and diffraction gratings: Placing the optics of the critical gaze in science education under erasure (after the critique of critique).

Following the orientation provided by the trailhead of Chapter 2, Chapter 3 asks if the metaphors through which the field of science education critically engages are (re)shaping the possible pathways for, and ways-of-navigating, inclusion of Indigenous science. (Re)considering critique within this chapter began with the notion that critique - the conventional mode through which the culture of dominance (e.g., Eurocentrism) within science education is challenged - has run out of steam (Latour, 2004a). As Latour (2004a) states, the very tools employed by critics have been appropriated by those who have been and continue to be its intended targets. As such, critique is easily reversed and brought to a standstill (as evidenced within Chapter 2). Thus, critique becomes protective (of positions, concepts, and categories) rather than productive (in seeking shared meanings) (see Spivak, 1976), unfortunately contributing to the (re)production of Indigenous science as yet-to-come within science education (see McKinley & Aikenhead, 2005; see also Kuokannen, 2007; Spivak, 1994).

Critique (in the conventional sense) is meant to (re)open possibilities for knowing and being otherwise. However, it presents itself as already prescriptive as a result of proposing particular ways of navigating its pathways. Such operationalization of critique enacts and upholds the very metaphysical structures worked against within this dissertation. Critique-as-usual (re)naturalizes many of the tools and strategies of (neo-)colonization and clôture (e.g., distance, separation, hierarchy, sameness/difference). Nonetheless, critique should not, and cannot, be dismissed. Its role continues to be central and critical in terms of (re)opening possibilities for Indigenous science to-come.

Considering critical engagement as epistemologically situated and metaphorically mediated allowed for the possibility of it to become otherwise. Approaching conventional critique as mirrored correspondence (see Barad, 2012a; Latour, 2004a) opened up space to differently journey the path of critique. This entailed contemplating optical metaphors whose differential metaphysics might allow: a) Indigenous science (to-come) to be more intelligible from within spaces of science education; b)
for the potential to reveal, as well as displace, (neo-)colonial structures and strategies that (re)center WMS (both implicitly and explicitly); and, c) for the production of differential modes of critique that might be more productive in being response-able and account-able towards Indigenous science to-

come.

Through deconstructive (mis)reading, what science education is (e.g., critique as mirrored correspondence) was substituted with what it is (not) (e.g., Foucaultian prismaticity, Baradian diffraction). Such deconstruction works to displace and disrupt, all the while upholding the structure one is working within. The re(con)figured practices of critique (i.e., prism and diffraction grating) differentially reveal otherwise taken-for-granted concepts, categories, knowings, and beings operating with/in multicultural science education¹⁶¹. These optical metaphors present unique contributions to the field. As Bazzul and Carter (forthcoming) state in their literature review of Foucaultian application in science education, there are but a few examples of Foucaultian critique within science education in general and, I would suggest, much less with respect to the particular context of Indigenous science. Inclusion of diffraction grating as critical metaphor is all-the-rarer as Barad’s (2012a) articulation of diffraction as critique is but recent, and the ontological turn only beginning to bear upon science education (see Scantlebury & Milne, forthcoming).

7.1.3 Chapter 4: Tinkering with/in the multicultural science education debate: Towards positing an ontology.

The continued excursion through science education presented with/in Chapter 4 entails wandering the pathways of multicultural science askew and obliquely by considering uncommonly considered, but ever-present, ontology. Journeying with insights garnered from the previous chapters reveals that ontology as singular, naturalized, and taken-for-granted comes to bear on the ways in which Indigenous science is to-come. In short, ontology at once acts as the handmaiden of Eurocentric and the (cultural) meter stick through which epistemological realism (i.e., the epistemology of WMS) is upheld and (re)centered. Here, Cobern and Loving’s (2008) call for ontological situatedness as a means of resolving the multicultural science education debate simply displaces the terms (e.g., presenting WMS as universal) rather than disrupting them: alignment

¹⁶¹ Furthermore, such metaphors invite a critical suspension (see Bohm, 1996; Foucault, 1997). As some of the issues facing the place of Indigenous science within school-based science education has been differentially (re)produced for decades now (McKinley & Stewart, 2012), it may be worth considering momentary suspension towards displacing (rather than attempting the impossible and never achieved destruction) of dominant logics (despite seeming counter-intuitive to pause amidst this critical contemporary moment in which Indigenous science is yet-to-come).
assumes and pre-supposes separation and separability, as well as requires mirrored correspondance (extending chapter 3’s metaphor of the critical mirror).

By extending critical alternatives from the previous chapter, science education is (re)opened to a differential considerations of ontology. They include: a) ontology as plural rather than singular; b) ontology as a metaphysical choice rather than pre-supposed; and c) the situation where the aforementioned ontological conditions are cuts one colludes in making, and such metaphysical choosing (re)opens ontological agency to one’s (distributed) ethical responsibility (see Barad, 2007). This invites the positing of an ontology and may begin by naming ontology, and produce movement towards accounting for and being accountable to what is produced and produceable within the (never-fully-stable) ontology of teaching, learning, and meaning-making with/in science education.

The deconstructive practice of tinkering (i.e., using tools intended for other tasks) utilized in Chapter 4 invites the reader to pay attention to the ways in which the ends and the means never fully coincide. One such consideration that is noteworthy is how tinkering asks for attention to practice, particularly those that get labeled as non-practices (see Spivak, 1976, 1988a, 1993). A highly significant example here is the enactment of ontology as practice (see Barad, 2007, 2010; Cajete, 1994, 2000), rather than pre-supposed.

**7.1.4 Chapter 5: Considering Cartesianism as an ontology within multicultural science education with Dr. Frédérique Apffel-Marglin.**

Chapter 5 extends the wanderings presented in Chapter 4 through continuing the work of tinkering within what it means to posit an ontology. Particularly, it explores what it might mean to position Cartesianism – the ontology of WMS – as an ontology in order to account for and be accountable to what it produces and makes produceable. A series of expert interviews with Dr. Frédérique Apffel-Marglin reveals that Cartesianism came to be operationalized in 16th and 17th century modern Europe as the result of a confluence of inseparable forces: economy, geography, military, politics, religion, as well as science. These were (and are) all working a metaphysics of clôture that, in its time and place (it’s there-then), worked to produce multiple forms of separation and separability. Notably, for the status of Indigenous science to-come, is the separation (and distance) produced between people who worked the land as knowledge-practice, from the land (i.e., the commons) and the knowledge-practices that were enacted through the spatial-economic practice of the enclosure (see Apffel-Marglin, 2011). Furthermore, through the birth of the laboratory and its associated technologies (e.g., modest witness in concert with other forces), science comes to be
constructed as *a-cultural* and *a-political*, etc; it appears to transcend bias. Considering diffraction invites attention to the ways in which these *there-thens* transposed into *here-nows*, as well as the (neo-)colonial knowledge practices through which this multiplicity of entangled knowledge-practices have been diffused and distributed (see Battiste, 2005; Blaut, 1993; Spivak, 1999).

While the contributions of Chapter 5 are multiple given Dr. Apffel-Marglin’s expertise on the “birth of modernity”, as well as why the metaphysics of modernity is a significant location to labour in accounting for and being accountable to Indigenous science to-come, I wish to highlight two *orientations* to decolonizing and post-colonial science education that diffractively emerge from this series of expert interviews. The first is the importance of privileging transdisciplinarity (see also Battiste, 2013b; Smith et al., 2016). Science, science education, and Indigenous science (to-come) are irreducible, always failing to fit within a single discipline. While this is a well-recognized quality of Indigenous ways-of-knowing-in-being (e.g., Battiste, 2013b; Cajete, 2000; Kaoméa, 2001; Smith et al., 2016; Smith, 1999/2012), science and science education are more likely to be framed with/in disciplinary logics (as a form of discipline, through the logics of self-sameness and not-otherness).

Remaining open to knowledge outside of one’s disciplinary tradition is not only an ethical move, but it is also one that is productive as knowledge-practice (see Bazzul & Carter, forthcoming). To follow the lived life of concepts and categories into other spaces allows one to consider their differential being and becoming (e.g., Battiste et al., 2005). Tinkering, as leveraging the un/common, is a remarkable practice of pursuing this productive supplement.

The second orientation, related to the productive supplementarity of transdisciplinarity, is considering the multiplicity of ways in which the metaphysics of individualism work to separate and make separable ecologies of relationships, as well as the ways in which they (inseparably) complement one another. One of the ways that this can be put into practice is, as signaled on the first page of the introduction, by considering entanglements and ecologies of relationships as extending beyond a *here-now* to a multiplicity of *there-thens*. In turn, the move towards Indigenous science to-come cannot and should not be considered a response to curricular *place-less-ness*, but rather *place-full-ness*. While place may not considered through an Indigenous sense of place, or even actively considered at all, place (i.e., proximal Nature-Culture, space-time-mattering) is never absent: place has its own agency that always comes to bear (see Barad, 2010, 2012c; Cajete, 2000; Lenz-Taguchi, 2010). The question of place becomes *which* place comes to bear (as well as when, where, and how)? As demonstrated within Chapter 5 (and introduced in Chapter 2), dominant conceptions of
knowing nature cannot be so easily disentangled from a laboratory there-then, which always already comes to bear on a here-now. To (too easily) suggest a conception of place without attending to the ways in which Nature-Culture already comes to manifest runs the risk of masking the workings of power (see McKinley, 2000).

7.1.5 Chapter 6: Responsibility, response-ability, and science education: Towards re(con)figuring science curriculum and pedagogy.

As the logics through which the metaphysics of modernity are (re)produced are circular, walking the pathways of science education may often feel as though it is a form of déjà-vu – although seeming sameness is always differential. In turn, breaking from modernist orbits requires focused, sustained efforts to work against slippage into processes dialectic negation of othernesss through which (neo-)coloniality is maintained. Nakata’s (2007a, 2007b) concept of the cultural interface provides a lived-conceptual location from which to consider the multiplicity of conflicting, contradictory, and co-constitutive interactions that occur between Indigenous metaphysics and the metaphysics of modernity. While such circularity is a boon, it is also a gift: resistance to dominance can happen in (almost) any location through which power circulates. This is, of course, with the cautionary note that not all locations are equally productive, and that some locations are a privilege to inhabit even if inhabitation is critical (see Spivak, 1988a). Furthermore, not all locations are equally pliable and pry-able.

To be responsible for the complex nature of the culture interface, one needs to be able to respond, to be response-able (see Kuokannen, 2007; Spivak, 1994). However, to be able to respond to that which is to-come requires that one be able to respond to that which one does not already know (Barad, 2010). Stated otherwise, one must be wounded by (the impossible) thought (i.e., penser) and forego the urge to clamp a dressing over the wound (i.e., panser). To work the possibility of getting lost beyond the circularity of the pathways of science and to be wounded by thought, I targeted two locations that are central to science education. Further, these locations displayed indeterminacy, thus making them pliable and pry-able and open to response-ability as deconstruction.

The first of these locations is scientific literacy. (Re)opening scientific literacy to other possibilities of “literacy” that work towards plurality and dialogue (i.e., not needing to negate other forms, but rather to situate them): agential literacy and ecologies of relationships (i.e., an Indigenous “sense of place”). The second location is vision. (Re)opening photovoice as a visual pedagogies
to(wards) the ontological plurality of agential realism and ecologies of relationships provides potential pedagogical moves that might work to break orbit from the metaphysics of modernity (e.g., “textual” juxtaposition as a post-representational move that requires the reader to relationally make meaning in-between elements as a means of rupturing the singularity of closure).

The practices of agential literacy, ecologies of relationships, and re(con)figured photovoice primarily come to inform the working within, against, and beyond science education presented in the following section outlining the Visually Storying Relationships with Nature project described.

7.2 Part 2: Wandering Within, Against, and Beyond the Pathways of Science Education: Visually Storying Relationships with Nature

As signaled earlier, the latter half of this concluding chapter continues to re(con)figure science education so that it might be able to account for and be accountable to Indigenous science to-come. Particularly, I (mis)translate insights learned through this dissertation research into a school-based educational setting, particularly a re(con)figured scientific literacy and visual pedagogy presented in Chapter 6. As translation is never fully achieved or achievable (Derrida, 1976), I attend to some of the (re)contextualizing factors that come to shape the ways in which the practices advocated for throughout this dissertation came to differentially bear on the unique pedagogical context I engaged as one component of this research. Kirk Gummow, the collaborating teacher with whom I worked, and I named our pedagogical project “Visually Storying Relationships with Nature”, which took place with/in his middle school classroom and beyond over the course of month. Here, and in line with a differential enactment of the third articulation of science to-come, I ask the reader to recall the following research question: What types of pedagogical practices might allow for and nurture the possibility of Indigenous science to-come? To engage with this (re)contextualizing and/as (mis)translation, I attend to three temporal movements of the project: before, during, and after.

Before comes to serve as a positional vignette that frames my relationship to both Kirk and the project that, at the time, would be in the design phase at the time. Furthermore, I introduce our shared and continued curiousity that is story, narrative, and the multiplicity of mediums it takes. During offers a rapid overview of the project as a whole, as well as some attention to the design and delivery of pedagogical nodes that were enacted during this month-long school-based project. Three activities are shared that attend to (mis)translation of approaches developed herein through story-ing processes: (meta)fiction, comic book theory, and Indigenous storywork. The discussion of
(mis)translation and story-ing approaches occurs in relation to the ways in which such tactical wandering of the pathways of science education allow for differentials ways-of-knowing-Nature (i.e., space, time, matter). Such wandering must not be without aim, but with a goal: “to liberate thinking about science education from the sedentary points of view and judgmental positions that function as the nodal points of Western academic science education discourse. What happens when we encourage random, proliferating and decentred connections?” (Gough, 2006, p. 268).

Furthermore, the notion of tactical wandering here is double(d) as it signals deconstructive pedagogy that is meant to (re)open spaces of science education, while simultaneously being a pedagogy that is quite literally on the move. For example, through a variety of mediums students were invited to wander spaces of learning and explore natural-cultural relations with the places of learning they inhabit that also inhabit them (see Lenz-Taguchi, 2010). After glances at pedagogical productions resulting from the delivery of Visually Storying Relationships with Nature. The inclusion of pedagogical productions animates discussion and demonstrates the ways in which such pedagogical configurations work against the ontological closure of Cartesianism to produce a different horizon of possibilities for decolonizing science education. The forms of scientific literacies explored within the previous chapter and carried forward this conclusion – agential literacy and ecologies of relationships – offer frames to read two youth-produced stories. Reading attends to the ways in which the forms enact a (re)opening of the space of responsiveness towards the ecology of relationships within which we as learners found ourselves, albeit imperfectly.

7.2.1 Before Visually Storying Relationships with Nature: Storying my relation to the project.

I could not even begin to speak to my relationship to the Visually Storying Relationships with Nature described within this chapter without discussing my relationship with Kirk Gummow, the collaborating teacher in the delivery of this school-based pedagogical project in (and beyond) his middle school classroom. This relationship is one that is marked by many roads and many signs that continue to inflect the paths we travel on together (e.g., preparation for facilitation of district-wide professional development sessions, the birth of his first child, informal Indigenous education dialogues). Like with my relationship with Dr. Frédérique Apffel-Marglin, it was a chance encounter that had meaningful ripples (see Peat, 2007): what began as an informal living room lesson on reading comic books with Indigenous storywork in mind (notably Steven Keewatin Sanderson’s Darkness Calls) as part of coursework for an Indigenous knowledges and pedagogies graduate

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162 This story is told with Kirk Gummow’s permission and approval.
program at the University of British Columbia, quickly became a friendship that extended beyond collegiality and collaboration. Being in relation with Kirk has and continues to take me in new and unexpected directions through a reciprocal relationship in which teaching and learning are not unidirectional, but manifest in flexible patterns.

Kirk is a practicing Métis teacher who is early in his career as an Aboriginal support teacher in Coquitlam School District #43 located on the traditional, ancestral, and unceded territories of the Kwikwetlem peoples which lies on the shared traditional territories of the Tsleil-Waututh, Katzie, Musqueam, Squamish, and Sto:lo Nations. From my perspective, Kirk’s engagement with theories and practices of Indigenous education has not ceased despite his recent attainment of a graduate degree. Rather, his engagement has intensified through the necessary translation and troubleshooting of contextualization into everyday school practices. Through our month-long collaboration and countless informal meetings, I continue to learn much from Kirk’s way of being in the world. Never assuming the hubris of fully knowing, he allows himself the vulnerability, the flexibility, and openness to be in dialogical relation, to be wounded by thought.

Kirk continues to engage with and through Indigenous ways-of-knowing-in-being to enhance his own understandings and guide his educational practice in new directions. Many of our meetings involve sitting down at Calhoun’s Coffee House in Kitsilano over a cup of coffee trying to make sense of a particularly rich, difficult, or daring passage of texts from authors like Tewa scholar Gregory Cajete, Seminole scholar Anne Waters, Papaschase Cree scholar Dwayne Donald, among others. With these texts, we would talk about the complex relations between knowing, being, spirit(uality), axiology, cosmology, and other co-constitutive parts of what is referred to as all my relations (see Cajete, 1994, 2000).

Many times, these engagements begin, or, more appropriately, are preceded by virtual salutations and prompts. More often than not, the salutation is a “Yo”, which has become our common form of greeting one another (as per a more recent exchange):

**Subject: Yo**

**From:** Kirk Gumnow <kirkgumnow@gmail.com>
**To:** Marc Higgins <mrhiggin@lakeheadu.ca>

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163 Nonetheless, over the course of the last four years, we have also engaged as colleagues to deliver professional development on our shared work, alongside these semi-regular discussions in which we “talk shop” regarding Indigenous education.

164 Alternately, and ironically, we have also met frequently at The Colony, a resto-bar in the same neighbourhood. The joke about decolonizing through occupying the space somehow never seems to grow old or stale. Rather, it is (re)told anew in light of different conversations.
Was wondering if you could help make sense of an excerpt I came across when you get a chance. Specifically the part that's underlined. No rush in fact we can just chat about it next time we talk. Thanks yo.

What is needed is a theory of métissage focused on colonial experience that demonstrates that Aboriginal peoples and Canadians have deeply historical relationships that continue to manifest themselves in ambiguous ways to the present day. An acceptance of this interpretation of history, however, hinges on the recognition that “there is no hors-Indigène, no geopolitical or psychic setting, no real or imagined terra nullius free from the satisfactions and unsettlements of Indigenous (pre)occupation” (Findlay, 2000, p. 309). This recognition is necessary to counteract the systemic ways in which Indigenous knowledge systems, values, and historical perspectives have been written out of the ‘official’ version of the building of the Canadian nation. (Donald, 2009, p. 9)

Yo Kirk,

I'm going to jam this out.

Here's the quick and dirty as I get it -- and here's where a bit of Derrida (which is hard [expletive redacted]) comes to bear, but it resonates a lot with Indigenous ways-of-knowing-in-being, so I'll bring it back. Bringing in extra pieces -- Derrida talks about how:

1. There is no "hors-texte" -- all meaning is inevitably connected in some way, shape, or form. We cannot cut away at meaning so easily -- especially when looking for "safe" locations (e.g., saying you work from a decolonizing location doesn't "protect" from colonizing slipping in -- the opposite, thank god, is also true).

2. Responsibility precedes being. Because these meaning is never separable, the relationships that make us precede us -- and so does the responsibility that stems with it. We have an ever-present responsibility towards the things that make us us, which is basically everything, just some things more than others.

Bringing this back to the quote:

1. There is no "location" that is "hors-Indigenous" such that Indigenous stuff doesn't come to bear: whether its a curricular area (like math!), or a political arena, or anything else (like, it seems here, a shared history!) -- Indigenous ways-of-knowing-in-being always come to bear, matter, and should matter. There is no "terra nullius" or blank slate from which to make meanings that don't or can't include Indigenous ways-of-knowing-in-being because...

2. That relationship always precedes us all (whether acknowledged or not) and we are accountable towards it (part of the work is being able to become response-able!). Here in the text, we can't tell stories of a Canadian past without bringing in "Indigenous (pre)occupation." John Ralston Saul talks about how a lot of what is referred to as "Canadian" history and politics is located between and beyond English, French, and Indigenous peoples (never wholly situated in one).
SO -- this theory of Métissage motioned might be about how any account is always or inevitably between Indigenous and dominant discourse (rather than one or the other) -- this hybrid and complicated space.

So if this sounds like a bunch of BS, we can chat over coffee or beer! :)

Marc

Such e-mails with dense passages articulating Indigenous philosophies, decolonizing theories, and/or traditional and community-based approaches to Indigenous teaching and learning (e.g., storywork, place-based) became the starting-point for many of our conversations, which often gravitated back towards a shared question of what it might mean to (mis)translate these passages into our respective and collective research, teaching, and learning practices.

This particular exchange above is salient as it points to the notion that resistance can happen anywhere (see Foucault, 1977): there is no hors-Indigène, no outside of Indigenous (pre)occupation. The possibility of being wounded by thought, specifically Indigenous science to-come, is always already present. Furthermore, as Battiste (2013b) suggests, decolonizing education invites a nurturance of a diversity of teaching and learning gifts: one of Kirk’s many gifts is locating such passages, desiring to open and be open to them, and (as an educator) wanting to share the learning journey.

Kirk’s coming-to-learn and teach through Indigenous storywork, my work in decolonizing science education with visual methods, as well as a shared active interest in place-based education would act as catalysts for developing and come to inform how we would collaborate on a month-long project. Lastly, we could, and would, take a cue from former students who reminded me that science is in everyday practices: such as inhabiting school spaces. We would collectively work towards telling stories of and, more importantly, with Nature.

7.2.2 **During Visually Storying Relationships with Nature: Science beyond a story.**

In short, *Visually Storying Relationships with Nature* was a pedagogical project involved two of Kirk’s middle-school classes in an urban school in Metro Vancouver for a one-month period. It encouraged participants not to “read” nature through scientific literacy but rather to narrate *with* nature as a form of agential literacy that fostered an ecology of relationships: producing photography-assisted comic books which told such relational stories *with* Nature. That is, Kirk and I endeavoured to design and deliver pedagogical activities that created conditions for students to pedagogically be wounded by thought (i.e., *penser*): to think Nature beyond the metaphysics of
modernity through which the wound of knowing nature is bandaged closed (i.e., *panser*). All of this is to engage with and tell stories that Nature (i.e., space, time, matter) might tell (with) us as a community of learners, were we able to listen anew through different attunement (see Barad, 2007; Cajete, 2006).

Producing a differential attunement to the ways in which matter comes to matter in school-based settings, as Lenz-Taguchi (2010) states, entails designing an “intra-active pedagogy” that:

…shifts our attention from only giving attention to the intra-personal ... and inter-personal ... to give explicit attention to the intra-active relationship between all living organisms and the material environment: things and artifacts, spaces and places that we occupy and use in our daily practices. (p. 11)

However, as this dissertation’s mantra differentially (re)states: there is a certain degree of pedagogical side-stepping or “wandering” of the pathways of science education required to respond (and to be able to respond) to Indigenous science to-come. This is because Nature often continues to be presented as separate, separable, static, and passive as in a WMS-based traditional “school science” (see Aikenhead & Michell, 2011). While differentially approaching science through other-than-Cartesian ontologies, this pedagogical “getting lost” works within/against many of the nodes of science: such furtive and deconstructive movements displace and disrupt rather than destroy the structure of science education. For example, the content of this project still included the “stuff” of science and scientific literacy (i.e., space, time and matter) and the process differentially privileged science’s visual empiricism (Peat, 2002).

In this section, I outline three activities designed and delivered that engaged students in further developing a relational practice and language that works towards knowing with nature within the context of their schools. Overall, these activities, as well as those not explored herein\(^\text{165}\), were intentionally designed to produce both a literal and a metaphorical wandering of their schools as places of learning in order to differentially know with/in them. As narrativity was such a central component to this work, I focus herein on activities that deployed various modes of storytelling as a means of displacing the story of science that often comes to overcode the ways in which nature’s

\(^{165}\) A non-exhaustive list of activities would include: a) stopping in places that were significant to students to take note of how this significance registered upon their bodies, in terms of the heart, mind, and body (e.g., senses); b) documenting these encounters and bodily significances through written notes, photography, and spatial mappings; c) learning about and through Indigenous storywork, its teachings, its medium, and how it has been dialogically interfaced with comics (e.g., Michael Nicoll Yahgulanaas’ *Red*); d) developing digital comic books creation skills, through the development of photography skills (e.g., composition), story-writing, -building and -boarding abilities, as well as learning about the aesthetics and technicalities of comic book creation, and the computer software used (i.e., *Comic life*; see http://plasq.com/).
account is given (and given over). For each activity, I: a) give a “thumbnail account” of the narrative mode through which science education is (mis)translated (i.e., (meta)fiction, comic book theory, and Indigenous storywork); b) describe the activity; and, c) present how this supports the possibility of Indigenous science to-come.

7.2.2.1 (Meta)fiction and an introduction to place.

Science education often presents science as the story of Nature. In turn, I ask what might it mean to treat it as but a story; a story whose enactment frequently signals longing and nostalgia for the one true story (see the One Truth in Chapter 5; Cajete, 2000; Gough, 2006). After all, as Cajete (2000) reminds, “science in every form… is a story of the world.” (p. 27, emphasis mine).

Similarly, Gough (2004) invites the treatment of science education not as (the) fact but as (meta)fiction\(^\text{166}\), as a style of writing that is not discontinuous from other forms of literature and that evokes a multiplicity of possible engagements with Nature. Furthermore, it is productive to consider both science as (meta)fiction but also (meta)fiction as science. This porous pairing (i.e., science ↔ (meta)fiction) is particularly salient as “much fiction (including children’s fiction but especially science fiction) is ‘more faithful to the aims’ of education than the ‘dogma and conceit’ of many contemporary education texts” (Gough, 2004, p. 258). Consideration entails recognizing that WMS and science education have their own rules of storytelling, characters, tropes, morals, and narrative arcs. In turn, space, time, matter, reliability, repeatability, scientists, experimental validity, and a rhetoric of conclusions, among others become but the rules and roles of that particular form of storytelling (see also Cajete, 2000; Gough, 2004). Thus, knowing nature is always culturally mediated and narrativized (see also Chapters 2 and 3). As “Western science and science education also tend to be written from a sedentary point of view” (Gough, 2006, p. 640), it is important to continue wandering within, against, and beyond the spaces of science education from which I began this inquiry. Accordingly, science education as on-the-move (literally and towards Indigenous science to-come) is not about wholly stepping away from the pathways of science education, but rather about wandering them anew.

The lesson that opened the Viually Storying Relationships with Nature employed such insights by presenting Kunio Katō’s (award-winning) short animated movie La Maison en Petit Cubes (see https://vimeo.com/14661112) to provide an example in order to ground a discussion.

\(^{166}\) Here, I employ (meta)fiction to signal both fiction (i.e., a story whose narrative is constructed) and metafiction (i.e., a fiction which employs literary devices to bring attention to the ways in which it is a constructed narrative, which questions the relationship between fact and fiction).
about place. As an animated movie, its very medium does not let one forget its status of (meta-)fiction: its enactment as a narrative whose playfulness between fact and fiction brings attention to its constructedness. Furthermore, given the central positioning of place as strong supporting character — the movie (acts as a platform to) explore(s) the role of place as both natural and cultural.

In short, the movie follows an elderly man’s relationship to a place that was significant to him. He (re)visits and is visited by memories past as his home is flooded by (surrealistically) rising water levels. This, in turn, became a productive pivot point to talk about the multiple dimensions of place that include Nature (i.e., space, time, matter), as well as extend beyond these nodes. This version of place as imbued with significance offers a tactical sidestepping of nature as “knowable” towards something that is familiar yet strange, and that begins from a sense that Nature and Culture are always already entangled. This includes, but is not limited to, how place can be anthropogenic (i.e., cultural landscapes that are not “pure” of human interaction; e.g., spectres of humanity across the Amazon rainforest; see Apffel-Marglin, 2011) while recognizing that its agency in producing meanings and matterings does not solely reside in its hybrid human-other-than-human relations. Just as the natural-cultural place enacted within the movie became a repository of memories, landscapes remember as they bear the markings of their own entangled becomings (see Apffel-Marglin, 2011; Barad, 2007; Cajete, 2000). “Hearing” the stories that place might tell requires attunement to the unique relationships that shape the ecologies of relationships we find ourselves in; an attunement Indigenous ways-of-knowing-in-being have practiced in places that have co-constituted these practices since time immemorial (Cajete, 2000, 2006). Furthermore, as students considered their own relationships to place(s), knowing was something that was at once cognitive and storied, and also sensory, emotive, and potentially even spiritual.

Additionally, as a “sense of place” is central to Indigenous science to-come, this became a productive point of departure for dialogue with students about how different places are significant for diverse people and peoples, starting with themselves and working outwards.

7.2.2.2 Comic book theory, the elements of the graphic novel, and collective (mis)readings.

McCloud (1993) defines comics as “juxtaposed pictorial and other images in deliberate sequence, intended to convey information and/or to produce an aesthetic response to the viewer” (p. 9). As comics theorist McCloud (1993) posits, the reading of comics requires a tacit relationship between author and reader. This is largely a function of the multiple processual flows of difference that must occur for a (or any) story to emerge. However, as meanings are never fixed (see Derrida,
1976), the indeterminacy of meaning is heightened through the multiplicity of dialogical pairs existing within a comic book: meaning-making is an entangled process that occurs in-between the elements of a comic book (e.g., panel-to-panel, image-to-text, panel-to-page, page-to-page) that are currently available to our field of vision (i.e., the two page spread). In other words, we are always “observing the parts but perceiving the whole” (McCloud, 1993, p. 63).

This is a phenomenon that is often referred to (and, to some extent, in alignment with its use up to this point in this chapter) as “closure” and it is one that occurs frequently when reading comics. Closure, in a nutshell, is the act of mentally completing our fractured and fragmented experiences of the world in order to make sense and ascribe meaning. Often presenting a largely incomplete and never complete-able ‘picture’ of what is happening in the in-between spaces, comics are representative of “a medium where the audience is a willing and conscious collaborator and closure is the agent of change, time and motion” (p. 65). As a rejoinder, Derrida (1976) suggests that “thought is … the blank part of the text” (Derrida, 1976, p. 93, emphasis in original). “Closure” here, as defined by McCloud (1993), is not thought as already thought-out, but rather the unknown and unknowable act of connecting rather than separating through intertextuality (see Baetans & Surdiacourt, 2011; see also, Spivak, 1976).

The spaces in-between panels are unceremoniously titled the “gutter” by comics enthusiasts and are a space of (mis)translating that forever allows the possibility of being wounded by thought. In moving from one panel to another, the implicit task at hand is one of taking two separate images and dialogically making an idea from them (recognizing that it need not and cannot negate the aforementioned image-texts). While “panels fracture both time and space, offering a jagged, staccato rhythm of unconnected moments…, closure allows us to connect these moments and mentally construct a continuous, unified reality” (p. 67). Lastly, McCloud also makes the argument that reading comics is a multi-sensory experience as “between panels, none of our senses are required at all. Which is why all of our senses are engaged!” (McLoud, 1993, p. 89, emphasis in original). The whole learner is always an absent presence. It is for this reason that McCloud (1993) states that the “gutter” is where “the magic” of comics happens 167.

167 However, as a cautionary note, comics are not “magically” less problematic comics differentially inflect and enfold society’s reliance on dominant (neo-)colonial narratives and stereotypes and occasionally amplify them for dramatic effect (King, 2009; Pewewardy, 2002). However, McCloud (2006) does remind that “no matter how many tons of ink we’ve spilled on it over the years, comics itself has always been a blank page for each new hand that approaches” (p. 252-253); comics’ possible possibilities productively vacillate.
Within the *Visually Storying Relationships to Nature*, one of the many ways in which comic book theory came to bear (above and beyond the final project of photography-assisted digital comic book production) was through an introductory lesson on the elements of the graphic novel. During this lesson, youth learned about the characteristics of the gutter described above, as well as a series of aesthetic choices intended to potentially produce response with/in a reader (e.g., choice of moment, choice of frame; see McCloud, 1993). This was followed by a group read along in which group discussion revealed that comics as text produce multiple possible possibilities for interpretation and narrativity. Furthermore, as we also explored how Indigenous authors have taken up the medium of comics, the substantive content of many of the comics were stories of *knowing-with-nature*.

Furthermore, learning about this medium offers new ways to think about representation as other-than-closure. As suggested of a re(con)figured photovoice for science education in the previous chapter, reading and producing comics provides a rich medium whose excessive intertextuality is not so easily swept “under the rug” through employing representation as mirrored correspondence. Comics invite the possibility of commensurable enactments of flux and relationality that mark Indigenous science to-come.

### 7.2.2.3 Indigenous storywork and graphically storying significant places.

Indigenous storywork is conceptualized and enacted as a multi-relational performative act in which the whole (i.e., the ecology of relationships) is enfolded in the part (i.e., the story). This entails the productive labouring of a variety of relations within the whole. First, it works to create an inter-subjective relationship between humans. Archibald (2008) states that Indigenous storywork does not prescriptively teach. Rather, not dissimilar to comics, storywork operates as a differential pedagogy in which the listener (or reader) is required to engage in a relational meaning-making practice:

> A synergistic action happens between the storyteller and story, but it is the storyteller who ultimately gives breath, or life, to the story. From listening to and reading what storytellers say about making meaning from story, I have learned that the traditional ways favour no or very little direct guidance from the storyteller. (Archibald, 2008, p. 112).

Secondly, it brings human interiority into relation; as Archibald (2008) states, “Indigenous storywork is not an easy process but it is essential to educating the heart, mind, body, and spirit.” (p. 143). Thirdly, storywork considers and brings into proximal relation an other-than-, and more-than-human exteriority. If we take seriously the notion that the whole is enfolded within the part,
storywork always already operates as a rich source of knowledge about the natural world that is commensurate with science education’s conventional way of understanding scientific literacy (see Barad, 2000). However, its differential strength is that it is conceived of and enacted as a way of knowing with nature (Barnhardt & Kawagley, 2008; Cajete, 1994, 2000). Lastly, knowing with and through story entails response-ability: “the communal principle of storytelling implies that a listener is or becomes a member of the community” (Archibald, 2008, p. 26). In other words, storywork is at once the gift of an invitation, as well as a responsibility that precedes being in the form of (re)telling and a living with a story (recognizing the story is always already translated into a new context and should not be self-same; see Derrida, 1976):

Practicing respect and responsibility in relationships with people and toward storywork led to a traditional concept of reciprocity. Within many Indigenous cultures, one is taught to pass on what she/he has learned to those who are interested. This passing on of knowledge is a way of perpetuating it. (Archibald, 2008, p. 126).

In short, Indigenous storywork can be said to be a differential articulation of Cajete’s ecologies of relationships articulated in the previous chapter – it is for this reason that place and story in Indigenous paradigms are often co-constitutive by design as place-stories (see Cajete, 1994, 2000; Donald, 2011).

Following an introductory lesson on Indigenous storywork within the Viually Storying Relationships with Nature project, students were encouraged to think with some of the principles offered by storywork to consider their own relationships in what could be referred to as a graphic reflection. Specifically, they were invited to consider places significant to them in and around the school-grounds and narratively reflect upon them with and through the aforementioned multiple dimensions of narrating relationships: inter-personal, intra-personal, inter-being, and ethical (see also Lenz-Taguchi, 2010). In order to engage in this task, students literally and tactically wandered about the school’s space in order to mindfully spend time in places (within place) that were significant to them. These places (e.g., the playground, the library, the forest) were photo-documented as a means of accounting for the other beings that come to constitute the place. Furthermore, students attended to the intra-personal dimensions by jotting down sensory and emotive cues (see Appendix E), and the inter-personal dimension through classroom discussions about why these places are significant to them, with/in their school, and as a place of learning. These multiple differential insights into significance of place were utilized to create student narratives through graphic reflection (i.e., a
comic, one-panel poetic narrative), providing opportunity for students to further familiarize themselves with the technical aspects of the project.

These activities, as well as those that are not included in this dissertation, served as building blocks towards the iterative cycles consisting of affective observation, photography, and visual storytelling that shaped the lead up to and preparation for the production of students’ photography-assisted digital comic books. In the next section, I read the results of the students’ comics mise-en-page (i.e., narrative arrangement of multiple visual textual elements; e.g., speech bubbles) storytelling and the ways in which they enact and are enacted by their everyday ecologies of relationships within (and beyond) their school.

7.2.3 After Visually Storying Relationships with Nature: Narrating with everyday ecologies of relationships as/and agential literacy.

In this section, two short narrative vignettes are presented and read with the other-than-Cartesian approaches that inform this work presented in the previous chapter: Barad’s agential literacy and Cajete’s ecologies of relationships (i.e., an Indigenous “sense of place”). Note that these vignettes are (not) the work of the students, at least not in the essentialized or unitary sense (see Appendix F and G respectively for the student produced comics). Rather, they are relationally (mis)translated for the purpose of this open-ended conclusion. Each are a differential telling of students’ visual-linguistic stories emerges through and between my reading of and with two students’ comic books that are with/in and beyond their school as an everyday ecology of relationships. Recognizing that the stories we tell are never ours alone (even if and when they are often primarily ours), it is worth highlighting the other beings whose agency came to bear on the production of these vignettes, albeit unevenly and unequally: student interviews, participant observations of pedagogical activities described, the school space, non-reflective reflexive (researcher) photography and videography, interviews with the collaborating teacher, and traditional Indigenous stories.

7.2.3.1 The diary of “The Diary of a Wimpy Kid”: Considering other-than-human bodies within schools.

Within the school, a girl enters the library to take out a book. A cacophony of consternate cries of “Pick me, pick me!” arise from various novels, encyclopedias, and graphic novels (kids simply don’t seem to read books as much as they used to). A big sigh of relief arises from The Diary of a Wimpy Kid when this student reaches for her and takes her to the librarian to sign her out. Excitement wells
“Going outside [the library]! What a rush!” What might the diary of the Diary of a Wimpy Kid hold for that day? Being stuffed in a locker? Being lovingly read? Being left in the wet grass of the playground?

While a library book is not the typical subject or object of study within the context of science education, there are still important lessons to be learned in considering this for, and as, decolonizing science education. Because books themselves are perceived as cultural repositories whose materiality is but a medium whose properties are taken for granted, it is important to consider the ways in which other-than-human bodies within schools are always already natural-cultural and participating agentially in entanglements in ways that come to matter. One of the first questions one might ask is when considering the following is: Whose narrative voice emerges through the telling of this story? Within Cartesian frames, one has few options. As stories are forms of knowledge, they require a cultural body to enunciate them. Here, this leaves our student author Danielle (pseudonym) as the sole source of voice that is telling a story about a book through projecting anthropomorphic values onto it. However, Barad (2007) encourages anthropomorphism (i.e., attributing cultural values to otherwise deemed acultural bodies) if it can be put to the service of working against anthropocentrism (i.e., the centering of humans). However, what if the story is actually narrated by the book?

Thinking with Barad’s agential realism and Cajete’s ecologies of relationships, and the points of resonance between, encourages considering the ways in which bodies that are typically considered natural, rather than cultural, to have agency. Furthermore, these lines of thought invite us to think about the ways in which agency is distributed and enacted intra-actively. Barad (2007, 2008) refers to the ‘doing’ and ‘undoing’ of intra-action as posthumanist performativity. This extends the Butlerian notion that epistemology is always already performative. Performativity, a persistent theme through Butler’s work, is the anti-ontological doing and undoing of epistemological categories, concepts, and conditions such as identity (e.g., Butler, 1990), ethics (e.g., Butler, 2005), framings (e.g., Butler, 2010). For Butler, there is no doer behind the deed or foundational essence behind epistemology, but rather, knowing and ways-of-knowing are always enactments within a citational chain. Barad (2007, 2008) extends Butler’s notion of performativity by including materiality as performative and co-consititutive of discourse. In turn, this grants materiality a similar flux and undecidability, and in the process extends the range as to which bodies can and do engage in performativity, as well as the norms by which bodies come into being.
Accordingly, the voice that would arise would entail, at very least, Danielle narrating with the book. However, the body who is voicing is simultaneously neither and both the book nor/and Danielle as they are classically conceived within a Cartesian ontology, as neither pre-exist their enactive entanglement (i.e., no doer behind the deed). Rather, they emerge from a re(con)figured narrative body which would comprise and cut across multiple Cartesian entities through a iterative process that is always already happening. Thus, there was no essential ‘Danielle’ or a ‘Diary of a Wimpy Kid’ prior to this entanglement. Rather, they were always already enactments of their ongoing material-discursive historicity of ongoing entanglements past, present, and to-come. This means that (re)considering the voice as an intra-active entanglement would entail accounting for, and being accountable to, a plurality of natural-cultural bodies within the ecology of relationships which come to constitute the phenomena at hand. While it is impossible to fully account for all of the agencies which might enact this narrative, which includes both Danielle and the Diary of a Wimpy Kid, their respective and intertwined material-discursive historicities and futures-to-come always already matter. Although, as Barad (2007) reminds us, while everything comes to matter, not everything comes to matter equally.

To begin to consider other-than-human beings as agentic is a deeply productive step in the direction of taking seriously Indigenous science to-come, particularly the Indigenous notion that the plurality of other-than-human bodies such as animals, plants, rocks, rivers, constitute a sentient landscape which is always already teaching us, should we choose to and/or be able to listen with (Battiste, et al., 2005; Cajete, 1994, 1999, 2000; Marker, 2015). As Leroy Little Bear puts it “trees talk to you, but you don’t expect them to speak in English or Blackfoot” (in Peat, 2002, p. 288).

It is also interesting and worth considering the other-than-human bodies that co-constitute schools, such as books, as de/colonizing agents – bodies who are positioned with/in the indeterminate space between upholding and subverting coloniality (see Battiste et al., 2005). While books are often considered as enacting knowledge as a thing-onto-itself that is already made, it is worth noting that while Cartesianism is totalizing, it is never fully totalized. Entangled within the production of the comic, The Diary of a Wimpy Kid acted as a pedagogical pivot that facilitated and enhanced already existing relationships. As Barad (2007) reminds us, the ways in which we enact our intra-actions matter because “each one reconfigures the world in its becoming – and yet they never leave us; they are sedimented into our becoming, they become us” (p. 394). In other words, the ways in which we enact our ecologies of relationships leave their marks upon the bodies connected
with/in the entanglement. One of the ways in which the entanglement of the *Diary of a Wimpy Kid* and Danielle can be accounted for is through considering the multiple ways Danielle might have differentially taken up the book’s ways-of-being-in-the-library.

One of such marks upon Danielle’s body, or ways in which she registered the entanglement, was through developing a more active version of her already existing relationship with the school librarian and library (e.g., learning about the everyday engagements of books, such as being shelved or loaned, through discussions with the librarian). To extend this line of thinking further is to consider the ways in which, as Battiste et al. (2005) posit, the very materiality of schools as institutions uphold and enact Eurocentric values: for example, books as intra-acting with/in neo-colonial knowledge commodification practices, re-centering the human of humanism. This has at least two important problematics and possibilities. First, it invokes a double(d) deconstruction (see Chapter 6) of schools’ binary relationship between nature/culture and inside/outside (i.e. nature+outside/culture+inside) in order to (re)consider schools as not only cultural but also “natural,” or more specifically as natural-cultural places. To only consider the “outside” of schools as natural spaces runs the risk of forgetting and neglecting the ways in which the inside of the school is always already enacting its very materiality. Secondly, while perceived as upholding (neo-)colonial values, it is worth considering the ways in which schools and their ecologies of relationships are never fully totalized and are already enacting subversive possibilities.

7.2.3.2 *Days of future past: Considering non-linear spacetime in science, technology, society, and environment issues.*

Elsewhere in the school, Bill (pseudonym) is becoming a future self that may never come to be. Space and time as Bill knows it have momentarily unraveled, unwound as Bill quantum leaps into an unknown and (im)possible dystopian future. Arriving upon the very school grounds he would have been have been a student at, he finds the site in disrepair and deserted. All that remains of the forest that should be surrounding the school is but blackened earth. With no one around, he begins to explore the ruins. However, suddenly, he is pulled back into the timeline he is all too familiar with as if awaking from a bad dream. What will Bill do with this knowledge of an uncertain but potentially possible and deeply problematic future?

A strong theme that permeates this story is the ever-present possibility of a future that is shaped by socio-politico-ecological disaster. Entangled with/in the story are conversations with the author George and other students which suggest a partial and distributed understanding of how he
and others are always already enacting (neo-)colonial systems. In other words, an understanding of the ways in which such systems privilege capital gain over growing social, political, and ecological concerns that result from ongoing processes such as the entangled unregulated resource extraction and pollution, and highly uneven (re)distribution of wealth as well as basic human necessities such as food, water, and space. As Smith (1999/2012, p. 58) reminds us about this entanglement, “one of the concepts through which Western [modern] ideas about the individual and community, about time and space, knowledge and research, imperialism and colonialism can be drawn together is the concept of distance”. By means of separability, separation, and distance through exclusionary individualism, the individual(istic) human(ist) subject can operate at a distance from culture, nature, and ethics. Metaphysical individualism obscures an ongoing accounting for and accountability to the ways in which we are always already iteratively, epistemologically, and ontologically co-constituted (Barad, 2007, 2010, 2012b). Further, engagement in the ongoing and ever-needed possibility of ethics is foreclosed (see also Apffel-Marglin, 2011; Cajete, 1994, 1999, 2000; Peat, 2002). Here, part of the pedagogical possibility offered by this story towards subverting a singularizing (neo-)colonial settler futurity is not only directly addressing the many ways in which the humanist subject maintains and (re)produces power through distance and separation, but also how humanism separates, distances, and organizes space, time, and matter (i.e., Nature).

Thinking with posthumanist performativity helps us think about the ways in which this story employs futurity and its subversive potentiality through ontological indeterminacy. Rather than using the language of predictability and certainty implied through a linear and causal relationship between past natural and cultural events towards an ever certain present, this story invites us to consider a natural-cultural future as a possible possibility that shapes the present with/in a non-linear causal relationship: Does the past produce the present? Does the present shape the past? What about the relationships with the future? On time, Barad (2007) states:

> Time is not a succession of evenly spaced individual moments. It is not simply there as substance of measure, a background uniformly available to all beings as a reference or an ontological primitive against which change and stasis can be measured. (p. 180)

For Barad, time is performative and comes into dis/continuous being through its enactment. This dis/continuous being, or to vacillate between being and not being, is, in short, what it means to be ontologically indeterminate. If even the past is open to being re(con)figured (e.g. quantum tunneling; see Barad, 2007) in the present, then what happens to the temporal linear causality that WMS relies
upon to make knowledge claims? What if time were always already an entangled variable to account for and be accountable to rather than a control (or controllable substance)?

This resonates with Indigenous ways-of-knowing-in-being that recognize that the world itself is in flux and in process such that it might be more appropriate to state that it is ontologically becoming rather than being. Such ontological indeterminacy has significant consequences for pedagogy. For Cajete (1994), “learning involves a transformation that unfolds through time and space” (p. 54) and that enfolds space and time (see also Peat, 2002). This is significant as it makes space for a plurality of ways-of-knowing-in-being to include other ways of enacting temporality such as Indigenous forms and flows of time such as non-Euclidian circularity (Cajete, 1994, 2000; Peat, 2002). Also, considerations of time as enfolded and time as always already more than an inert, immutable, and linear backdrop upon which nature and culture play-out invites a ongoing consideration of the ways in which time makes itself intelligible through its entangled performativity with other agencies.

The ways in which multiple space-time-matterings make their presence known in singular instances in bi-directional causal ways (Barad, 2007; Cajete, 1994, 2000; Peat, 2002) invites us to not only consider how the past shapes the present and the futures-to-come, but also how the plurality of undeterminable futures shape the present, as well as the past. This non-linear causality invites us not only to consider how we are shaped by potential futures-to-come, but more importantly, how we are always already ethically bound to these potentialities that we can never fully come to know. “Everything leaves a track, and in the track is the story: the state of being of each thing in its interaction with everything else” (Cajete, 1994, p. 55-56). Potential futurities are always already with/in us. However, just as this story ends with the protagonist waking up from what seems to be a bad dream, there is always an ethical hope in the subversive potentiality of the future as it is always at once yet-to-come and not-yet-to-come.

7.3 Conclusion: Indigenous Metaphysics is (Still) Waiting in the Wings of Science Education

The dissertation is now reaching its close. Indigenous metaphysics is still waiting in the wings of science education within the scope of this dissertation, and is neither wholly nor hospitably received on the main stage of science education. Nonetheless, I elect to conclude with a message of affirmation. What appears as an absence or a next-to-nothingness is not lack, a mere criticism, nor a critical negation. Rather, it is a potential relationality, a co-constitutive moment and movement to-come.
As Barad (2012c) suggests us in *What is the measure of nothingness?*, even nothingness is itself is a doing that is rife with possibility and potentiality. This is even the case for what is classically understood as “pure” nothingness: the vacuum of space. As she states,

> From the point of view of classical physics, the vacuum has no matter and no energy. But the quantum principle of ontological indeterminacy calls the existence of such a zero-energy, zero-matter state into question, or rather, makes it into a question with no decidable answer. Not a settled matter, or rather, no matter. And if the energy of the vacuum is not determinably zero, it isn’t determinably empty. (Barad, 2012, p. 8-9)

Rather than this determinability being a question of epistemological uncertainty, it is one of ontological indeterminacy, “the indeterminacy of *being/nonbeing, a ghostly non/existence.*” (Barad, 2012c, p. 12, emphasis in original). Even the smallest of particles vacillates between being a something and a nothing. It is rife with potentiality as it is never “just itself”; it is co-constituted and co-constituting a plurality of other particles and particles-to-come. As she states, “even the smallest bits of matter are an enormous multitude. Each “individual” is more up of all possible histories of virtual intra-actions with all Others. Indeterminacy is an un/doing of identity that unsettles the very foundation of non/being” (p. 15). This has consequences for ethics (as co-constituted by epistemology and ontology, of course): “Individuals are infinitely indebted to all Others, where indebtedness is not about a debt that follows or results from a trans/action, but rather, a debt that is the condition of possibility of giving/receiving” (pp. 15-16).

As Indigenous science already displays and has always deployed “ingenuity, creativity, resourcefulness, and ability of people to learn and to teach a harmonious way of existence with Nature” (Cajete, 2000, p. 78), the possibility of hospitably *receiving* Indigenous science is not only an ethical call; science education can learn much from Indigenous ways-of-knowing-in-being and its practices of relational balance, (re)generation, and renewal. Thus, wandering the pathways of science education to heed the call of Indigenous science to-come matters even if it is but a possible possibility: “matter is never a *settled* matter. It is always already radically open” (Barad, 2012c, p. 16, emphasis mine). Nature (i.e., space, time, matter) is and was never fully totalized within (neo-)coloniality. It is with hope and affirmation that I end: *Indigenous science is still yet-to-come.*
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Appendices

Appendix A  E-mail Invitation to Participate in Expert Interview

Subject: Introduction, Summer Indigenous Education Institute in Peru, and the possibility of an Interview
From: Marc Higgins <mrhiggin@lakeheadu.ca>
To: Frédérique Apffel-Marglin <apffel.marglin@gmail.com>
Date: Thu, Feb 14, 2013 at 12:08 AM

Hello Dr. Frédérique Apffel-Marglin,

My name is Marc Higgins. We have met, albeit very quickly, during the talk that you gave at UBC last spring (in March if I recall correctly) that Peter Cole and Pat O'Riley hosted. I am currently a doctoral candidate whose past (and likely future) work is somewhere between Indigenous education, and (creative) science and technology education. As the work I have done and am planning on doing deals more so with pedagogical doings than with curricular knowings, I recently developed a keen interest in (new) materialist feminisms (and on this note I should perhaps say that I am concerned with coming-to-knowing-through-being?). I find this emergent body of knowledge in which scholars like Karen Barad are situated very pertinent for working within and against Western (and often colonizing) constructs, as well as a great deal of potential connections with notions of Indigeneity. While there continues work to be done in making further links, I very much appreciate your recent Subversive Spiritualities (as well as your earlier edited collection, the Spirit of Regeneration) and what it achieves in working across Indigeneity through material/discursive frames, as well as beyond the nature/culture dichotomy which often excludes spirituality through its duality.

I am signed up for the summer institute in Peru this summer and am very excited to hear more (and perhaps, just as importantly, learn in ways which are often dampened by the walls of the academy). Furthermore, if you would be willing, I would love to interview you and engage with your work. I’m certain that we will likely engage in a rich conversation or two regardless, but I think that what your scholarship provides a rich "diffractive reading" of Indigeneity and (new) materialism and would be interested in incorporating your voice as an 'expert interview' in my doctoral writing (from which a dialogical exchange, either literal or metaphorical could take place -- I have been reading some of Karen Barad's more recent work [e.g., 2011, 2012b], and there are ideas there that are ripe for discussion!). Please let me know if you would be open to this and we can continue a conversation from there.

I am looking forward to hearing from you and learning more this upcoming summer.

Thank you.

Marc Higgins
Appendix B  First Expert Interview – Becoming, Being, and Doing Reverse Anthropologist

1. a) You state very early in Subversive Spiritualities that the book is the fruit of a lifetime of ethnographic practice. However, you also speak to your falling out with the anthropological tradition as the knowing-in-being implicit to the many and varied practices and your ethics were at odds. In your departure from convention, you are becoming in the process what you refer to as a reverse anthropologist. Could you speak to some of the events which marked your life and in turn lead to the production of this position?

b) Furthermore, what brought you to write this book?

2. You make clear that this reverse anthropological position is not one that is simply about studying those who do the studying (i.e., in order to reverse the ethnographic gaze), but also, and more importantly, to study the way in which those who do the studying study (i.e., in order to reverse the way the ethnographic gaze is produced). It is, by definition, a double(d) process. Why is this distinction so important and how is it productive?

3. a) The challenge you lay out for yourself in the task of attempting to reverse the production of the ethnographic gaze is certainly not a light load as you work both within and against the anthropological tradition: as Patti Lather quizzically questions us, how do you think about how you think without using the thing with which you think? Nonetheless, in working towards the possibilities that emerge when we strive for the impossible, you identify interdisciplinarity as a rich site of engagement. Irrevenrently piecing together historical intra-disciplinary spaces, as well as working across disciplinary spaces, you produce a sort of bricolage which mangles together history, economics, science, regional socio-politics, and more. What were the patterns of difference that emerged through this particular entanglement, and how did this aid you in avoiding some of the conventional piftfalls that are implicit to the knowing-in-being of ethnographic practices?

b) Furthermore, you identify interdisciplinarity as a productive strategy that can aid in working towards holism, albeit at the expense of hyper-specialization. Why is this holistic vision both important to and productive for the work that you do?

4. a) Within your work, disciplinary cuts are not the only ones that are under observation and being re(con)figured. Rather, there are many dualisms resulting from cuts that are addressed therein (e.g., nature/culture). Taking seriously the double(d) inversion of the ethnographic gaze that you speak of, you work with/in a theoretical framing which not only addresses these dualisms but also works towards understanding how these dualisms are produced, and what they produce, in turn in order to (un)do them differently. In the double(d) reversing the ethnographic gaze, you identify and work (within/)against a Cartesian-Boylan-Newtonian framework. Could you speak to how this framework (re)produces anthropology, how anthropology (re)produces this framework, and why it is a point of engagement that is of critical importance (for anthropology as well as other fields who have inherited this framework)?

b) Furthermore, you identify the work of Karen Barad as a productive tool for engaging with and for thinking about the production of the (dichotomous) cuts that are made with/in a Cartesian-Boylan-Newtonian framework. How does the work of Karen Barad aid you in the double(d) process of inverting the ethnographic gaze (i.e., both in terms of critically addressing the structures produced
through a Cartesian-Boylan-Newtonian framework as well as how such a framework produces such structures; e.g., the ethico-onto-epistemological phenomena of representation)?

c) Lastly, if we are always already making cuts, be they Cartesian or other, what kinds of cuts might such a framework allow for, and how do these cuts work towards reversing anthropological processes?

5. Given that the work of Karen Barad signals the return of metaphysics and motions towards thinking with/in and through what Niels Bohr calls "quantum wholeness", it may be worth addressing the question that is often asked with respect to thinking about lessons learned through quantum physics: why think with a theory of the small when addressing something much bigger?

6. Lastly, if we take the work of Karen Barad seriously, we are invited to (re)conceptualize that which has always already been entangled: knowing, being, and ethics. Just as questions of knowledge and being are not separate, neither are those of ethics; we enact ethics through our knowing-in-being. Could you speak to how this entanglement invites you to re(con)figure your (reverse) anthropological processes? (e.g., learning with rather than learning about).

Is there anything else you would like to add?
Appendix C  Second Expert Interview – The (Re)production and Operationalization of the Nature/Culture Binary and What it Produces

1. a) Within the previous interview, you spoke of many of the dichotomies that you are working within and against through your reverse anthropological work. Recognizing that to disrupt one binary is to disrupt others which are related to it, one of the key dichotomies that you center in your work is that of nature/culture. Could you quickly describe how you understand culture and nature within this binary pairing?

b) It is largely discussed within feminist and post-structural literature that, through a metaphysics of mutual exclusivity and separation, the first term of any dichotomy is dominant over the latter. Furthermore, the first term is constructed oppositionally to the second, making the latter its abject other. What consequences does this bear upon nature as well as those who are considered "natured" (i.e., rather than cultured)?

c) Despite the prevalence and pervasiveness of this binary, like others, it is always already deconstructing. Could you quickly speak to some of the examples within recent scholarship that you develop within your work that speak to the porosity of this binary (e.g., cultured nature and natured culture - such as cultural landscapes)?

2. While binary thought is always being produced anew, its origin (if we can say there is one) is largely, and often, attributed to the 17th century scientific revolution and, more specifically, the work of Rene Descartes, Robert Boyle, and Isaac Newton. Why are these three key figures in the production of what is often referred to as a mechanical, clockwork universe and binary thought?

3. a) Within your book, you make clear that "the scientific revolution was not the result of decades of discoveries, but was in the making for centuries" (p. 33). While it is important to speak of Descartes, Boyle, and Newton when (re)tracing the production of the nature/culture binary amongst others, this is not to say that the scientific revolution revolution from which it is often attributed origin was not entangled with the social, political, religious, economic and other events, tensions, and forces that were happening at the time as well as the time which preceded it. Could you speak of the state of the European subject historically the "tipping point" of modernity (i.e., the scientific revolution)?

b) Furthermore, while ideas and ways-of-thinking, like the Cartesian-Boylian-Newtonian framework, are always being (re)generated, those that "stick" (and stick around) are those that are operationalized and become embedded within the matrix of power/knowledge. While Descartes is often attributed dualistic thought (i.e., cogito ergo sum), you state that it was Boyle who operationalized it through his "technologies" of the scientific laboratory. What did these entail and how did this work towards the operationalization of the nature/culture binary?

c) Also, in your work, you focus on the phenomena of enclosure (or the material-discursive production of bodies of land) as a rich exemplar of how binary thought, separability, and, in particular, the nature/culture binary get operationalized and woven into the fabric of everyday life through the entanglement of abstracted systems of mathematics and economics, as well as politics,
religion, geography and other (often thought of as separate) natural-cultural forces. How did these various forces intra-act to produce what you call the "encloser's advantage" and what does this entail for the nature/culture binary?

d) Lastly, what did the operationalization of the Cartesian-Boylan-Newtonian framework entail for what is often referred to as pre-modern European society? What ways of knowing-in-being where disentangled and what did this produce?

4. a) While the nature/culture binary was operationalized during the 17th century, it continues to be (re)produced as we have entered the 21st century. Dualism and separability, in general, (re)frame the world in a manner that is pervasive, insidious, and often taken-for-granted. One of the rich exemplars you give of this within your work is the ways in which Western modern science (WMS) supersedes Indigenous ways-of-living-with-nature in the global South. Within this process of supersessionism (which could be said to have an almost religious quality to it, perhaps because the church was involved), you identify an addiction to certainty and objectivity/subjectivity as one of the ways in which the nature/culture binary plays out. Could you elaborate upon this process?

b) Another rich example that you give of the pervasiveness of the nature/culture binary is around the (onto-epistemological) violence that occurs when liberal Western feminist frames (shaped with/in a Cartesian-Boylan-Newtonian framework) are applied to Indigenous communities within the global South in the name of liberation and emancipation. Above and beyond the ways in which a Western metaphysics of individualism disrupts relationships of community between human, other-than-human, and more-than-human bodies (both through a metaphysics of separability and privileging social individualism as the pinnacle of social progress), one of the particular violences that even more progressive feminist frames would (re)produce is the silencing of the fluid materiality of the body. How does the nature/culture binary silence this, and why is it important to consider the skin of the body as a porous boundary (for Indigenous communities, and beyond)?

Is there anything else you would like to add?
Appendix D  Third Expert Interview – From Representationalism to Performativity:

Re(con)figuring and Troubling the Universality of Space, Time, and Matter

1. Throughout your book, one of your persistent critiques is that of the practice of representation and the onto-epistemological framework through which it operates and is upheld. To re-present, means to present again in a same or similar manner something which is different or not itself. Accordingly, this attribution of sameness or likeness within representation is only possible within a metaphysics of separability in which the observing subject is entirely separate from the observed object. Your critique is not only one of foundational approaches to representation (i.e., everything is representable; subject/object correspondence) but also one of anti-foundational approaches (i.e., every thing is representation; no subject/object correspondence). Could you elaborate upon the problematics that both of these approaches (re)produce?

2. a) Before proposing an alternative, it is important to understand that which we are working within against, or we risk (re)producing similar problematics albeit in a different context. From your reverse anthropological positioning, you act as an interdisciplinary historian of the Cartesian-Boylan-Newtonian (and its many dualisms) which produces anthropology and which, in turn, (re)produces the framework. As a dualistic practice which is deeply entangled with/in this framework, representation also has its own intra-active history in which the patterns of difference within converge. As you mentioned in your last interview, the operationalization of dualisms such as nature/culture requires systems of abstraction through which different qualities and quantities can be compared and contrasted. Could you give a "thumbnail" of some of the key historical nodes along which the development of mathematics as a form of representation occurred?

b) Could you also quickly speak to notable moments in history in which language and representation are enmeshed?

3. a) Not only does representation require a script through which its actors act their parts, but it also needs a stage on which it plays out. As you explain within Subversive Spiritualities, representation requires stable, universal, space, time, and matter for socially-constructed signs to correspond to it (i.e., foundational approach) or to act as a passive surface on which they play out (i.e., anti-foundational approach). Whether space, time, and matter be considered through an essentializing or anti-essentializing framework, they end up being explicitly or implicitly enacted as universal in that they are characterized as separate, and more importantly, always and already being there. While you have given at length a history of the production of universal matter (i.e., nature), could you encapsulate some of the key moments which lead to its production?

b) Furthermore, could you quickly speak to the way in which linear, uni-directional, and homogeneous time was (re)produced and operationalized? (e.g., the mechanization of the clock).

c) Lastly, could you do the same for the way in three-dimensional, recti-linear space was (re)produced and operationalized? (e.g., the 'birth' of perspectivalism).

4. a) While representationalism has gone largely unquestioned for centuries, and furthermore unnoticed or taken-for-granted, there has been a hiccup within the (often privileged) language (and
discipline) of (Western modern) science mid-20th century which caused a stutter, and stop for a second: the resolution of the wave/particle duality *gedanken* (i.e., thought experiment) via quantum physics experimental practice (i.e., the dual-slit experiment). While this might have been but a hiccup as the business-as-usual of representation (be it foundational or anti-foundational) has continued, if taken up seriously, the (onto-)epistemological consequences for this experiment are considerable. Leading up to the resolution of the dual-slit experiment, there were two competing theories with respect to the (universal) properties of electrons and other such small particles: one camp believed that they displayed the properties of waves and the other that they displayed the properties of waves. Through the dual-slit experiment, suddenly both sets of properties were observed, causing more confusion than resolution. From this confusion, two theories (and theorists) emerged: Heisenberg's (epistemological) uncertainty principle and Bohr's (onto-epistemological) complementarity principle. Could you, without getting too deep within the physics nitty-gritty, unpack the differences that matter between these two positions?

b) From these two theories, Niels Bohr's theory of complementarity emerged 'victorious' and has significant ramifications that extend beyond the scope of wave/particle duality within quantum physics. One of the more immediate conclusions from this theorizing has to do with the agencies of observation with/in experimental conditions (i.e., observer, observed, apparatus of observation). How does Bohr's work re(con)figure observation?

c) While science hiccuped, this monumental hiccup is often only noticed within (Western modern) science, and within quantum physics at that (e.g. "Why should a theory for sub-atomic particles have bearing on macro physical or social phenomena?"). However, this is not to say that there are no consequences for those within and outside of science as it challenges both foundationalist and anti-foundationalist approaches to theory/practice. If ontology and epistemology are no longer separate but are rather onto-epistemology, what might that mean for many of the concepts (and associated practices) that we use? (e.g., agency, objectivity, causality)

5. a) Working from and with the theory-building that Karen Barad has done (building upon Niels Bohr's physics-philosophy), you put to work one of these many re(con)figured (and entangled) concepts to work: posthumanist performativity. When first articulating thoughts about performativity, Judith Butler reminded us that there was "no doer behind the deed" (Nietzsche), that there was no essence behind the representation. From her anti-foundational position, performativity is about doing and undoing epistemology (e.g., identities, concepts, frameworks, paradigms) (i.e., epistemology is in flux through a citational chain. However, when ontology and epistemology are no longer separate but rather entangled, performativity is deeply re(con)figured (especially when considering the other intra-acting concepts which are also re(con)figured such as agency and realism). What is so significant about posthumanist performativity (e.g., working against anthropocentrism, identifying Cartesian cuts as but one of many types of agential cuts, distributed material-discursive agency)?

b) Furthermore, if we (re)consider space, time, and matter as entangled and fluid (i.e., spacetime-matter) rather than universal and fixed, what might this entail for posthumanist performativity?
6. a) Above and beyond acting as the interdisciplinary historian of the (re)production of Cartesian cuts and their intra-acting theory-practices, one of your major contributions to this (re)new(ed) conversation is a serious consideration for thinking about the distributed agency enacted through posthumanist performativity to include not only human and other-than-human bodies, but also more-than-human bodies. Could you talk more about the importance of spirituality in your reverse anthropological work, both in terms of learning with those with whom you work as well as reversing the (production of the) ethnographic gaze?

b) Considering how there is no place for spirituality within either foundational (i.e., because it cannot be represented "objectively") or anti-foundational frames (i.e., because it is only a representation), what does posthumanist performativity offer you within your work?

c) Furthermore, as you mention within your book, "the times seem to be ripe for devising a way of knowing in which accountability is built in" (p. 110). Because we are always already in relation, the world, in its quantum wholeness, is open to being to being re(con)figured to allow for different possible possibilities in the world's ongoing becoming. However, some possible possibilities that are enacted through posthumanist performativity might be more desirable than others. A lesson from those with whom you have learned with, and central to your work, is the notion that ritual is a regenerative enactment of the world that is sustaining bio-cultural diversity. Could you speak more to the performativity of ritual and (re)generation?

Is there anything else you would like to add?
Thinking about place: a place that is important to you

1. What is a place that is important to you? (Draw it in the box).

2. Where is this place?

3. Why is this place important to you?

4. What are some of the qualities of this place? What do you see, smell, taste, hear, touch, and feel emotionally when you are in this place?
HELLO, I AM A BOOK. MY NAME IS "DAIRY OF A WIMPY KID". I AM A FAMOUS BOOK IN THE SCHOOL OF THE STORY. I HAVE BEEN A BORROW BY A GIRL. AND NOW, LET'S SEE MY TRAVEL!!!

WHO SAID I'M A WIMPY KID???
AT THE LIBRARY

OKEY, SURE!

HI MRS. [NAME] I WANT TO BORROW THIS BOOK

THEN THE GIRL WENT TO THE HALLWAY.

STUDENTS ARE PUTTING THEIR STUFF IN THEIR LOCKERS.

OH, IT'S A FUNNY BOOK!

YES, I AM....
In those days, she always read me at lunch.

And she always go to the playground........

Actually, I don’t like playground, because there is so loud and many students play there.

But there also has nice thing, like air is fresh, you can see many green things to protect you eyes.....

Finally............

Page 2
There, you feel silence, quietly......

Then, she returned me to the library......

But, I miss that playground a little .......

THIS IS THE BOOK STORY....

page 3
THE END!!!!!
Appendix G  It’s Just a Dream (Student-Produced Comic)

IT'S JUST A DREAM!

HOPE YOU LIKE IT!
Ah, nature is sososososososo good. When I breathe, it makes me feel refreshed.

I feel very tired. Ahhhh. It's time to sleep.

The school locker is so brand new! Touch! It feels so smooth and clean.

It's time to dream. You glasses man... ha ha! Enjoy it... ha ha!

20 years later...

Time travel over 20 years later...
AH! WHERE AM I? I FEEL VERY DIZZY!

IS THIS? IS THIS? OH MY GOD, I CAN'T BELIEVE IT.

I KNEW IT. THIS IS MY OLD SCHOOL. WHAT HAPPENED? WHY DOES IT LOOK SO OLD?

SO THAT MEANS THAT THIS PLACE IS \ldots{} THE FOREST!

I NEED TO GO INSIDE TO SEE WHAT HAPPENED?

WHAT THE SMELL? WHAT HAPPENED? EVERYWHERE IS FULL OF ASHES.
WHAT THE SMELL? WHAT HAPPENED? EVERYWHERE WAS FULL OF ASHES.

IT WAS JUST A DREAM! SHU!

EN! SO GOOD! I FEEL VERY REFRESHED!

HI! MICHAL AND SUMMER!

AH SO GOOD! EVERYTHING BECOME NORMAL!

The End