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 chapter¹ is to explore what Foucault refers to as “the” critical attitude and its relationship to science education. Excavating the concepts that linger and lurk when critique is presented as atheoretical in science education, the following chapter engages with the *theoretical* homework of response-ability. 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 yet-to-come. Specifically, the adversary mode therein not only 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). In turn, I posit that (an) unsettling criticality is not only one which critiques settler colonial logics and practices but also the taken-for-granted ways-of-critiquing which can undergird these very efforts.

Building on the insight that scientific knowledge-practice is always already situated from the previous chapter (e.g., WMS's 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 grating²—to analyse and inform how the critical gaze might be re(con)figured within science education.

As critique is always in relation (Foucault, 1997), 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 account³ of the crisis of the critical stance (Latour, 1993) is presented with attention to 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; Deleuze, 1988; Foucault, 1997) 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, 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).

THE SUBJECT OF CRITIQUE: MY RELATION TO CRITIQUE IN/OF SCIENCE EDUCATION

Because we need to “begin” some-where and some-time, let's begin in St. Catherine's, Ontario in May of 2014.⁴ During the 42nd annual *Canadian Society for the Study of Education* (CSSE) conference, I am giving a talk titled *Post-Cartesian possibilities for schools as places of learning: Putting to work an intra-active pedagogy* (see Higgins, 2016). During this presentation, given on a curriculum studies panel, new possible possibilities for critique and critical engagement began to bubble; not as the result of my own work, but rather an insightful comment about the ways

in which I was being critical. Significantly, I was being invited to consider the ways in which “the” critical attitude is but *a* critical attitude.

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). This was very much in line with the ways in which I was approaching criticality at the time: as a formal and informal science educator for over 10 years at the time, I had become (and continue to be) 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). It would not be long before I familiarized myself with the multicultural science education debate in which questions of “what counts” as science are asked, by extension what counts as valid course content within school-based science curriculum. Largely at stake within this debate is the inclusion or exclusion of traditional ecological knowledge (TEK) and Indigenous ways-of-living-with-nature (IWLN) alongside Western modern science (WMS), as well as the norms through which they are included, excluded, and juxtaposed. This debate is largely between science educators who champion the inclusion of TEK and IWLN as an equally valid ways of knowing nature (i.e., cross-culturalists; e.g., Snively & Corsiglia, 2001) and those who do not consider these place-based ways-of-knowing-nature as *equally valid* to the “universal” standard of WMS (i.e., universalists; for example, Cobern & Loving, 2001). Note that *equally valid* here 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).

Guided by the questions: *Who is included?*, *Who is excluded?*, and *What norms shape how participation is and can be enacted?*, I had 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, 2014; McKinley, 2001, 2007; Sammel, 2009).

While these critical explorations and enactments were deeply fruitful for me in working towards decolonizing goals, they also revealed the ways in which Eurocentrism circulates in capillary⁵ 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, 2014; see also McKinley, 2001; Sammel, 2009).⁶ Alternately stated, despite the ways that available decolonizing curriculum and subject positions of teacher-as-researcher worked within and against a problematic centre, 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 continues to be diverse, productive possible pedagogical possibilities that stem from de/colonizing approaches, not all opportunities are equally productive (see Spivak, 1988, 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).⁷ However, 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.

This was precisely the insight that was presented to me following the presentation. During the question period, Dr. Kent den Heyer, a co-pañellist then and colleague now, 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,” and that accordingly, “Descartes would be rolling in his grave” (K. den Heyer, personal communication, May, 2014). 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 judgement; they were disposable and to be disposed of. 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.

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; Kirby, 2011; Latour, 1993, 2004a). 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 implicitly⁸ 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, 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)figuring *s*: 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).⁹ 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 manoeuvred 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,¹⁰ 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, 1983; 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 *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).¹¹

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 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, 2011). 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 in Derrida, 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 3 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, 2011).

Like any and every structure, there are many self-transgressive 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 possess, 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. lxxv). 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)reading¹² 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).¹³ 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 (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. lxxv). 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)*.

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 judgement (Barad, 2012a; Bohm, 1996; Butler, 2001; Foucault, 1997; Kirby, 2011; Latour, 1993, 2004a; Moulton, 1983). 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. 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 (see also Barad, 2007; Latour, 2004a, 2004b; Kirby, 2011). 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 deconstruction¹⁴ 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*)¹⁵ by denying the epistemological and ontological stability required for socialization and naturalization. These statements are, respectively, 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,¹⁶ 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, 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*).¹⁷ 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 their 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 “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 3, 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.¹⁸ This configuration downplays, and often negates, the impact that culture plays in the construction and implementation of modern scientific and technological knowledge (e.g., Matthews, 1994; Siegel, 1997, 2001). A critical and, more specifically, 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” (Barnhardt & Kawagley, 2005, 2008; McKinley, 2007; 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 *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.¹⁹ 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., Matthews, 1994; Siegel, 1997, 2001).

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 3), 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-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 sixteenth-century cultural practice of the “modest witness” in the laboratory?²⁰ 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?²¹ 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 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 productively (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.

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 condition, offering instead an optical configuration through which "statements or visible things *are dispersed*" (Deleuze, 1988, p. 43). In particular, Foucault (1997) 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 cannot 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)²²

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 differently.²³

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, 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 *someone*: 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 with/in the 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 elsewhere.²⁴

To frame prismatic critique, it is important to note that Foucault was a scholar critical of the Enlightenment. In particular, Foucault’s (1997) exploration centres the fundamental critical question characteristic of Western Europe in the fifteenth and sixteenth 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 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*.²⁵

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 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).²⁶ 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 (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 (2004a) 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 judgements 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 judgements altogether?

Returning to the question of "what counts" as science within the context of cross-cultural science education (from Chapter 3), 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 judgement 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 judgements 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 judgement 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 into 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” disperses 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.

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, 2007, 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 more 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 commonplace 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 pre-giveness (i.e., presence) 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, 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 visibility 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.²⁷ In short, Barad’s metaphor of diffraction invites a more nuanced and complex understanding of the natural phenomena informing 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 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 phenomenon 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 metaphysics²⁸: 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 (see Barad, 2010, 2011).

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.²⁹ 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.³⁰

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.³¹ 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 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 interact 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)³²

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)³³; 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, or diffractive critique, 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 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 3). Recall that like Foucault’s prismatic critique, Barad’s diffraction questions the a 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 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, 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., *matters of fact* and *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 *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, 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?

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.³⁴ In other words, the very tools of dismantling a normative centre have been absorbed by the centre and have been redeployed against the margins: the argument that the dominant position is but *a* situated and partial position is, through metaphoric subtraction, 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, 2014). 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.

Summing it up, three optical technologies which metaphorically inform, shape, and (re)produce ways of being critical were explored in this chapter: 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 operational.³⁵ 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.

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 augmented. Latour (2004a), by cheekily referring to this behaviour as sub-critical,³⁶ 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 producible in order to (re)open the structure of science education towards Indigenous science to-come. This might include (re)considering the debate as operating through an adversary paradigm (see Chapter 3), the role of (*an*) ontology within the construction of “what counts” (see Chapters 5 and 6), or even the complex and complicated relationship between Indigenous and Western ways-of-knowing-in-being (see Chapter 7). 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 unsettling science education and (re)opening it towards Indigenous science to-come.

NOTES

1. An earlier and much shorter version of this chapter appears in the journal *Cultural Studies of Science Education*, volume 13, issue 1 (pp. 185–203), and is reprinted here with permission.
2. While not taken up in this chapter as such, 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.
3. The expression of a "thumbnail account" is a euphemism that Apffel-Marglin (2011; see also Chapter 6) often uses that is not so dissimilar from Spivak's (1976) treatment of "in a nutshell" (i.e., attempting to contain the uncontainable in the name of brevity). 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.
4. The mantra of beginning some-where and some-time is not only a persistent reminder that we are always already within the question of Indigeneity within science education, but also an invitation to address it as such. Similarly, we must address it *some-way* and that elsewheres and elsewhens that come to bear on the very question are rife points of examination (here, in relation to criticality, we can trace back taken-for-granted understandings and enactments to 15th or 16th century Europe).

Further, as Kuokkanen (2007) invites us to consider, in revisiting the question of "debating" the inclusion of Indigenous science from the previous chapter:

What is required is openness to and responsibility toward the “other”, and this in turn requires a certain level of comprehension of indigenous epistemes. As importantly, it requires that individuals and institutions commit themselves to a critical debate about “cross-cultural” education, and that this education involves more than just integrating new material into the curriculum. The academy needs to recognize that the logic of the gift calls for changes to the ways knowledge is perceived and approached; moreover, well-intentioned individuals will need to be well equipped to deal with the complexities that emerge when different epistemes meet. (p. 108)

This is not to say that we should be debating whether or not Indigenous science is included, as is the central case of the multicultural science education debate. Rather than a call for less critical debates, it is an invitation to engage critically otherwise: moving from debates of inclusion/exclusion towards more nuanced conversations about *how* we might go about meaningfully including Indigenous science *can be* and *should be*. However, to work beyond “integrating new material into the curriculum” (p. 108) as critical engagement requires that we commit to critically examining and “debating” the very terms that constitute the contemporary conversation: the very notions of “cross-cultural education,” debate, and every other relevant concept and practice that we inherit which shapes our (in)ability to engage in the question of Indigenous knowledges within science education.

5. For Foucault (1977), power is not located within subjects or objects but is rather the relation between them through which power circulates.
6. See Chapter 2 for a lengthier, generative exploration of this problematic rupture.
7. In *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, 2014). 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).

8. 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 offered by Deleuze (1988).
9. 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, sedimented into how we come to know scientific phenomena.
10. Chapter 3’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).
11. 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).

12. 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).
13. With respect to vision, 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). As vision 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), it often smuggles in naturalized and normalized dominant theory-practices; it becomes a critical location to work within and against.

In turn, the importance of shifting the gaze from vision (i.e., sight, goals) to visualization (i.e., ways-of-seeing) cannot be understated, because of the ways in which who and what is seen, as well as how and where sight is regulated, both literally and metaphorically reinforce dominant ways-of-knowing-in-being while diminishing and denying the validity of others. For example, 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)

However, given “the plurality, hybridity, and ambiguity of visual practices,” attending to vision (either literal or metaphorical) provides a significant critical and complicit location “for unpacking old and new colonialisms” (Battiste et al., 2005, p. 9).

14. Within science education (Aikenhead, 2006a; Barad, 2000; Erickson, 2000), 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, 2000). 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, 2012b; Kirby, 2011) by subverting their stability, it is often unwelcome within science or science education (Barad, 2000, 2011).

15. 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).
16. Within Chapter 3, I address in greater length the notion that taking an oppositional stance, what Moulton (1983) 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.
17. Latour (2004a) uses *fact* (*fait*) and *fairy* (*fee*) because of their similar etymological roots. In short, both *fait*(*fact*) and *fee*(*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 6) 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 (5 and 6), 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).
18. 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).
 19. 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).
 20. The following is a thumbnail history of the “modest witness”. In Western Europe in the seventeenth 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 6.
 21. 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, 2014; Higgins & Kim, 2019; 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).
 22. As Smith (1999/2012) states, such an *enactment* of distance (via separation and separability) cannot be torn asunder from the “specific spatial

vocabulary of colonialism which can be assembled around three concepts: (1) the line, (2) the centre, and (3) the outside” (p. 55). Not only do these three concepts that are almost always at play in (neo-)colonial logics produce notions of hierarchy through proposing a center and a margin, the drawing of the line between them signals an oppositional difference. In science education, we often see these logics at play when the case for WMS’ centrality is (increasingly implicitly) made: it is heralded as the way of knowing nature because it is framed as not being the orientations that it is defined against, such as TEK and IWLN. This is further complicated by the ways in which (neo-)colonial logics and the metaphysics of *clôture* simultaneously work “to make the ends coincide with the means” (Spivak, 1976, p. xx), as explored within the first chapter. Stated otherwise, the practice of distancing which precedes hierarchizing is often naturalized and normalized as being one and the same as its resulting knowledge claim of distance. Such coalesced claims inevitably suture over the relations and processes irreducibly enfolded within them. The desire to make the ends coincide with the means results in the production of cultural difference without needing to account for or be accountable to the ways in which this difference is produced (e.g., Western modern metaphysics) or what this produces in turn (e.g., Eurocentrism).

23. Reflexivity is the often-cited solution for 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 (2014).
24. As Spivak (1976) reminds us, every translation is always already unfaithful (i.e., never achieving sameness) due to the precariousness of intertextuality.
25. While the work of Michel Foucault is relatively common within education, it is less so the case within science education (see Bazzul & Carter, 2018). 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, 2000), post-structural approaches are often un-welcome(d) (see Barad, 2000, 2011) and, accordingly, under-explored.
26. Spivak (1988) 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.
 27. I take the time to unpack the concept of diffraction here as the impact of Karen Barad's work and interrelated 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., Milne & Scantlebury, 2019).
 28. Recall that "Derrida uses the word 'metaphysics' very simply as shorthand for any science of presence". (Spivak, 1976, p. xxi). Within the sciences, the "master-question is the same as that of all Western metaphysics: 'What is *the* being of the entity?'" (Spivak, 1976, p. xxxiii, emphasis mine). This is to say that classically within the sciences, there is, generally speaking, *a* way-of-being to the scientific phenomena under observation. However, with the two-slit experiment, *being* (and in turn, ontology) is no longer a singular affair to be observed: "so much for the solid confidence, the assured certainty, the bedrock consistency of science, at the brink of a new century... classical metaphysics has misled us" (Barad, 2010, pp. 252, 256). As a result, we are left with unsettling questions or, perhaps more productively, an invitation to consider the ways in which *nature deconstructs* extending far beyond the ways in which "nature" deconstructs (i.e., the ways in which socio-scientific cultural meanings are always-already slipping into self-transgressive moments of irruption) (see Kirby, 2011), as well as what this might mean for science education (see Wallace, Higgins, & Bazzul, 2018).
 29. 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.
 30. 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, 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.

31. While beyond the scope of this chapter and book, Barad (2007) proposes that while the panopticon may be exemplary of observational technologies of the eighteenth century, ultrasound technology can be thought of as a more contemporary example of an apparatus of observation that is produced by and producing the phenomena it is meant to observe (i.e., *gendering*).
32. While not taken up within this chapter, Barad's (2010) "new calculus of response-ability" resonates with Kuokkanen's (2007) conception of response-ability in that both invite us to respond to a world which is rendered invisible through commonplace ways-of-knowing-in-being. Reading one through the other, for diffraction patterns, invites consideration of the ways in which Western modern science's inability to respond to naturalistic phenomena that do not fit within classical metaphysics might be entangled with the inability to take seriously Indigenous ways-of-living-with-Nature above and beyond (neo-)colonial socio-cultural dynamics.
33. 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.
34. 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 3 is an example of how these logics permeate the multicultural science education debate, unproductively.
35. Spivak (1993/2009) refers to this practice as "strategic essentialism": a critical inhabitation of truth-telling and representation through essentialism that works relentlessly to undo its own essentializing. See Chapter 6 for further discussion and use thereof.
36. Thinking with Alan Turing, Latour (2004a) defines a sub-critical engagement as one in critique is done through *subtraction*: "an idea presented to such a [sub-critical] mind will on average give rise to less than one idea in reply" (Turing 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.

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