

After this nothing happened

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Abstract In response to Michiel van Eijck and Wolff-Michael Roth's article and Michael Mueller and Deborah Tippin's rejoinder, we explore traditional ecological knowledges as science education. Adopting a stance of situated partial perspectives, and drawing on selected literature in science and technology studies and feminist postcolonial theories, we reflect on acts of dissociation, localism, utilitarianism and principled pluralism as referent points for epistemological and pedagogical renewal. In conclusion, we return to an opening narrative of cultural loss combined with an invitation to imagine science pedagogy as a site of possibility, vulnerability and fragility. Such an invitation, we suggest, involves troubling manifestations of pedagogical and epistemic desires of normative closures and certitude. What now remains is a series of tensions and open questions for further work.

Keywords Vulnerability · Science pedagogy · Situated knowledges · Traditional ecological knowledge (TEK) · Science and technology studies (STS) · Feminist postcolonial perspectives

This review essay addresses issues raised in Michiel van Eijck and Wolf-Michael Roth's paper entitled: *Keeping the local local: Recalibrating the status of science and traditional ecological knowledge (TEK) in education* (published in *Science Education*) and the rejoinder by Michael Mueller and Deborah Tippins entitled: *van Eijck and Roth's utilitarian science education: Why the recalibration of science and traditional ecological knowledge invokes multiple perspectives to protect science education from being exclusive*.

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Prelude

Just before he died, the great chief of the Crow Nation, Plenty Coups, told his story to a White Man, Frank Linderman:

When the buffalo went away the hearts of my people fell to the ground, and they could not lift them up again. After this nothing happened. There was little singing anywhere. “Besides,” he added sorrowfully, “you know part of my life as well as I do. You saw what happened to us when the Buffalo went away.” (cited by Lear 2006, p. 2)

Although Linderman repeatedly tried to get Plenty Coups to talk about anything that had happened after the Crow were confined to a reservation, it was almost as though time had stopped after this point. Jonathan Lear (2006) turns to Plenty Coups’s claim about the world in which there exists a point after which nothing happened. His ethical inquiry is not to determine the point of collapse, or even the antecedents that might have led to this, but to highlight a possibility that we might all prefer to forget, a peculiar form of human vulnerability, something that we all need to live by and with. This is not the familiar vulnerability of illness, injury, disease or even death, but a vulnerability of a different cultural type. The possibility that our ways of doing things within the world are in danger of becoming undone and in danger of becoming our undoing. A way of life that could in the future collapse. And if a cultural breakdown is a possibility, it is something we must live with, even when we perceive our culture as robust, and if we might never have to face this eventuality. Indeed, Lear goes so far as to suggest that living with this very possibility is part of what makes us human. What should this mean for science education? What might it mean to imagine science pedagogy as a site of such vulnerability and fragility? How ought science and science education live with the very possibility of their own demise? We return to this shortly.

Our story so far

This article continues the conversations initiated by van Eijck and Roth (2007) in *Keeping the local local: recalibrating the status of science and Traditional Ecological Knowledge (TEK) in education* published in *Science Education*, and the rejoinder by Mueller and Tippins (2009) *van Eijck and Roth’s utilitarian science education: why the recalibration of science and traditional ecological knowledge invokes multiple perspectives to protect science education from being exclusive*, published in this journal. Human beings have been called the story-telling animals. As children we tell stories to ourselves privately and to our playmates publicly to make and remake worlds of possibility. As adults we can take this story-telling capacity into wider realms of transformative politics. So we begin our story.

Whose knowledge gets to count as knowledge in science education? How can we make science education more representative of multiple cultural knowledge claims? How should we think about the question of TEK in/as science education? The aforementioned articles explore the role and status of traditional ecological knowledges with the desire to challenge the status of Western Modern Science (WMS) in science education and push back hegemonic forces that serve to render local knowledges to the peripheral status of *other*, as judged in relation to the prioritized, elevated status of WMS. What now remains is the pedagogical question of how to de-privilege WMS in science education, to disrupt the

threat that this science has brought—and continues to bring—to bear on pedagogical practices? On this question the pairs of authors both agree and also differ.

To de-privilege Western Modern Science in science education, Michael van Eijck and Wolff-Michael Roth (2007) advocate utilitarianism; advancing the advantages of embedding epistemic and pedagogical discussions and judgements within particular social, cultural and local ecological contexts. Their arguments seek to overcome the multicultural-universalism debate and in search of a way of uniting these well-worn binary positions they look to develop epistemology that simultaneously entails both *culture* and *physical reality* by rejecting a position of *truth* and adopting utilitarianism as a measure of the validity of knowledge. This position also embodies the dynamic, heterogeneous, and plural nature of products of human beings and understandings. Cultural Historical Activity Theory is used to analyse simultaneously available *WSÁNEĆ*, a Coast Salish peoples, and scientific narratives concerning the annual Northwest Pacific salmon run. The upshot of this analysis is that although science and TEK are both forms of knowledges, the artefacts of these knowledges, the authors suggest, cannot be understood apart from the distinctive cultural-historically determined human activities in which they emerged and consequently are irreducible to each other and thus incommensurate. A pedagogical conclusion drawn from this argument is that learners should learn to generate knowledge in pursuit of actions within collaborative culturally heterogeneous communities with shared/negotiated utilitarian goals. Such a position advocates that science education should adopt local contexts—social, cultural, economic, political and environmental—in which several literacies are brought to bear on problems and situations of shared concerns and agencies.

Michael Mueller and Deborah Tippins' (2009) rejoinder offers elaboration and modification to van Eijck and Roth's perspective by highlighting some of the tensions in van Eijck and Roth's arguments and building a case for considering more dynamic, dialectic relationships between sciences and traditional ecological knowledges in science education. Their desire is to ensure cultural diversity in science education as a principled way to make curriculum choices by embracing an enlarged system that identifies commonalities for TEKs and sciences. Such arguments, they suggest, challenge tensions associated with epistemological demarcations, hierarchical and dualistic categorizations as well as challenges associated with utilitarian epistemic judgements. They highlight and celebrate the depth of scholarship that has paid careful attention to documenting the numerous ways in which science should be seen as creative expressions of diverse communities and not the sole product of Western post-enlightenment thought. They also highlight the exciting range of ongoing cultural studies in science education and the work that colleagues continue to do to legitimize aboriginal sciences.

So, the authors share common concerns regarding the undesirable and unwarranted hegemonic influences of WMS in science education and the need to overcome the multicultural-universalism debate that overtime has become polarized and polemical. However, their desires for a successor science education differ. van Eijck and Roth's hope is that TEK and science should be recalibrated because they are culturally and materially incommensurate and such recalibration is possible on utilitarian grounds. Mueller and Tippins say that recalibration serves to attribute science with a special status in relation to other knowledges. They suggest that an enlarged system which identifies commonalities for TEK and science is most likely to produce the equality and equity needed for TEK to be taken seriously and reference contemporary examples of curricula of this type in various parts of the world.

In this article we explore partial perspectives and acts of localism, utilitarianism and principled pluralism as referent points for epistemological and pedagogical renewal.

Drawing on selected literature in Science and Technology Studies (STS), Feminist Studies, Postcolonial Studies and Environmental Studies, we explore arguments prompted by the dissociation of Science from the sciences and the hopes of science education subverting dominant forms of Science. We conclude by returning to our opening story of Plenty Coup and vulnerability. In part challenging the status of Science, we suggest, is about challenging the manifestations of certitude in pedagogies as well as epistemologies and this leaves us with a series of tensions and open questions for further work. Consistent with this point, our discussions are not framed as answers or solutions, but hope to offer some thoughts on complexities. Throughout these discussions we join with the authors in highlighting and celebrating the depth of work that has sought to explore the hopes and possibilities of TEK in and as science education. Sustained work has incrementally sought to bring about changes through *cross-cultural* approaches to science teaching and multi-cultural approaches in which WMS is just one of many sciences that need to be addressed in classrooms. Mueller and Tippins' article provides a fulsome list of work in both these areas, and this might be updated with recent publications that include a recent special edition of the *Canadian Journal of Science, Mathematics and Technology Education* (2009, vol. 9).

Privileging partial perspectives

Well, it's one pound for a 5 min argument, but only eight pounds for a course of ten.¹ As Monty Python reminds us there are weaknesses in entrenched, antagonistic dualisms. We echo van Eijck, Roth, Mueller and Tippins' concerns about TEK and science education stumbling back once more into competing camps of *universalism* versus *multiculturalism*. In reference to the science wars, Hilary Rose (1997, p. 64) once commented that "dreams come into existence not through binary confrontations but through multiple conversations and complex alliances." The epistemology and pedagogy that we commit to throughout these discussions is pluralistic and partial; it hopes to attend to many voices, many languages, and many cultures. Of course, such a positioning needs to be especially attendant to those voices that have over time been silenced and overwhelmed, lost in the shadows of dominant historical, socio-political *natural* orders.

Polemics, it is often written, can obscure the richness of dialectical and dialogical reasoning. Such positioning serves, perhaps, to do little more than sustain arguments and reassert established hierarchies. The processes of separation seek to demarcate clean positions and accentuate differences rather than celebrate commonalities, collaborations and shared concerns. What becomes lost is a sense of diverse hybrid imaginaries, shared common heritages and ways of making sense of differences. Dualisms immediately raise questions of power and privilege. Who benefits from such divisions, why and how? Here, we follow Hannah Arendt's (2003, p. 63) natural aversion to existing categories of knowledge that announce the certainty of any one interpretation. As the late philosopher and ecofeminist Val Plumwood (2002, p. 101) observed dualisms "create a radical discontinuity between the group identified as the privileged 'centre' and those subordinated." Plumwood identified dualisms as sets of inter-locking oppressions that police the boundaries against any unlawful flow of ideas across the divide, for example, between culture and nature or science and TEK. In her analysis of the power of dualisms to oppress, she outlines five characteristics of how inter-locking oppressions hold power in colonizing

¹ This is a line from the Monty Python Sketch entitled *Argument*.

practices by: (a) back grounding, (b) radical exclusion, (c) incorporation, (d) instrumentalism, and (e) homogenisation.

Traditional ecological knowledges are frequently back grounded. As van Eijck and Roth lament, WMS's authority serves to marginalise knowledges that become framed as mere *noises* on the margins of systems. Here, high-status compulsory educational practices are, of course, implicated. Historically, TEK has been excluded from the school curriculum and offered space in lower status optional courses in higher education. Radical exclusions (Plumwood's second characteristic) are, perhaps, too easy to observe as numerous examples drawn from studies in the history and philosophy of science document how the processes of formation of scientific institutions (such as the Royal Society) determine what epistemological practices count and even more significantly which do not. Systems of power, as Michel Foucault reminds us, produce the subjects that they come to represent. This is the case in science as it is in schooling and science education itself.

Plumwood's third characteristic about the incorporation of colonized peoples' knowledges by the colonizer has been repeated throughout history, from settlers being taught by indigenous peoples how to survive in their *new-found lands*, to the increases in patenting of TEK and biopiracy (Vandana Shiva 1997). Mueller and Tippins are particularly sensitive to issues of incorporating TEK into Science as an add on. Both articles are careful to discuss Plumwood's fourth and fifth characteristics of oppressive dualistic structures—the functioning of instrumental value and the homogenisation or essentializing of quite diverse indigenous cultures.

As van Eijck and Roth note *universalism* and *multiculturalism* are both statements of absolutism (positivism and relativism, respectively) and as such they actually have much more in common than their proponents, perhaps, care to imagine. Such dualistic reasoning, as the authors note, is unsettled through an abandonment of *truth* based on the relationship between cultural knowledge and the physical world. Without *truth*, it appears, we can escape our work becoming log-jammed between opposing philosophical camps. And yet, what is seemingly desirable, on further reflection perhaps opens up a succession of questions. In what sense should truth be abandoned in an absolute or transitory sense? Is abandonment to be read as a universalised proclamation? Is it a statement of certainty concerning the representation of external reality? Or is this loss of truth to be read as a suspension of belief as point of philosophical argument? There is ambiguity here. A similar point could be made regarding van Eijck and Roth's establishment of *incommensurability*. While we join with the authors in celebrating the explanatory possibilities of Cultural Historical Activity Theory, we also share concerns raised by Mueller and Tippins that to build a case for the incommensurability of TEK and Western Modern Science seems a return to where we started, oppressive dualisms. Incommensurability, as Mueller and Tippins point out "creates the presumption that there is no chance for common ground." Such positioning draws a clean line and outright dismisses possibilities of shared hybrid imaginaries. We must remain consciously aware of who benefits from the claim that science and TEK are incommensurate? Is there not the chance that this demarcation will become exploited through the mapping of these claims onto underlying hegemonies? In this regard, we join with Mueller and Tippins in nurturing the merits of epistemological pluralism and *relationality epistemologies* (Barbara Thayer-Bacon 2003 as well as Donna Haraway's (1991) partial truths and situated knowledges, and Evelyn Fox Keller's (1985) dynamic objectivity).

The flattening of power relations lying dormant in epistemological pluralism propels us to directly contest the incommensurability of TEK and scientific truth. Haraway's (1991) chapter, *Situated knowledges: the science question in feminism and the privilege of partial*

perspective states that “drawings of inside-outside boundaries in knowledge are theorized as power moves, not moves towards truth” (p. 184) echoing van Eijck and Roth’s attention to Foucault’s regimes of truth. The power differential between TEK communities and Science practitioners has a prolonged, convoluted past that lingers with us today. TEK as a specific embodiment of local natural history knowledge has been simultaneously used and sidelined by dominant scientific knowledge. Haraway clarifies the irresponsibility of unlocatable knowledge and also warns us about the dangers of subjugated knowledges relegated to the peripheries.

The standpoints of the subjugated are not “innocent” positions. On the contrary, they are preferred because in principle they are least likely to allow denial of the critical and interpretative core of all knowledge. They are savvy to modes of denial through repression, forgetting, and disappearing acts—ways of being nowhere while claiming to see comprehensively. The subjugated have a decent chance to be on to the god-trick with all its dazzling- and, therefore, blinding—illuminations. “Subjugated” standpoints are preferred because they seem to promise more adequate, sustained, objective, transforming accounts of the world. ... Relativism and totalization are both “god-tricks” promising vision from everywhere and nowhere equally and fully, common myths in rhetorics surrounding Science. (Haraway 1991, p. 191)

Mobilising for change

The rhetoric and ideology of Western Modern Science has, of course, been widely discussed and its hegemonic effects extensively documented. Stanley Aronowitz (1988, p. viii), for example, writes that: “the genius of science, unlike religion or philosophy before Kant, has been its ability to identify the absolute with knowledge or nature.” In his latest book on the politics of nature, Bruno Latour (2004) invites us to start with a dissociation; we are asked to dissociate Science (singular and capitalised) from the sciences (plural and small letters). He then goes on to define Science as the “politicization of the sciences through epistemology in order to render ordinarily political life impotent through the threat of an incontestable nature” (p. 10). Such a move serves to dissociate the local, discursive, material practices that constitute the practices of the sciences (Joseph Rouse 1996), from the rhetorical threat that Science brings to bear on the exercise of politics as well as the practices of these sciences themselves. With the construct WMS there are always problems of essentialism. As Mueller and Tippins comprehensively demonstrate, the genealogy (and contemporary practices) of WMS are neither exclusively Western, nor (we would add) have they ever been, or will be, especially modern (see Latour 1993). While the dissociation of *Science* from *sciences* has a series of weaknesses (as these are clearly not mutually exclusive) it might help to slightly broaden the question that the articles are grappling with, and in so doing respond to some of the tensions of essentialism. The problem is now not only how to remove the threat that Science brings to bear on traditional ecological knowledges but also includes the threat that Science brings to bear on all knowledges including the sciences themselves (and including Western Modern Science). In these terms, perhaps, what we seeking is a pluralist science education dissociated from Science. Such aspirations have much in common with Sandra Harding’s (2008) project of framing the *successor sciences* as critical feminist empiricism. What we need, above all else, is a science pedagogy that carries with it a notion of the collective/public good. An education that in Donna Haraway’s words, “insists on a better account of the world” and within this

process, to return to Haraway, “it is not enough to show radical historical contingency and modes of construction for everything” (Haraway 1991, p. 187).

In the current era of education this seems especially important. Increasingly we are subject to education research assessments and desires of research *Gold Standards*. In such games one has to be ever conscious and wary of the disturbing influence of Science beyond its playpen out into a pharmaceutically driven, insurance laden and dangerously militarized world. Benjamin Baez and Deron Boyles (2009) recent book eloquently dissects the politics of education research and the omnipresent *culture of science* wielded to steer centralised accountability and standardising reforms. The point is that what many of us hold dear in education is under-threat by slippery questions of enhanced empirical objectivity, questions which are more often than not framed by ghostly manifestations of Science. The enhanced status of Science in education is not only a curriculum issue but also profoundly shapes the culture of our institutional practices as educators and researchers. The question, as always, is how can we mobilise for change against such seductive and powerful reasoning?

Paradoxically perhaps there might be a revealing discussion in mobility itself. Latour (1988) once provocatively posed the question of why do Newtonian laws of physics work as well in Gabon as in England? As Warwick Anderson and Vincanne Adams (2008, p. 182) write:

Laboratory science, defetishized at its origins still moves around the Globe as a fetish, with its social relations conveniently erased. It seems to arrive with capitalism, “like a ship,” then magically arrive elsewhere, just as powerful, packaged and intact. We remain attached to the “Marie Celeste” model of scientific travel.²

Over the past decade, scholars of Science and Technology Studies has sought to understand such mobility in terms such as vectors, *boundary objects* and *immutable mobiles*. But there is still very much an open question as to the vectors and mobilities of science education, and the ways that our educational and schooling practices are implicated in launching and sustaining “Mary Celeste’s” voyage.

Mobility is actually a central theme of the two articles under discussion. The conversations between TEKs and science are conversations between knowledges from *somewhere* (a culture living on the West coast of Canada in van Eijck and Roth’s case study) and knowledges seemingly from *nowhere* (such knowledges include sciences and most other university based knowledges as well, of course). There is enormous power in the view from *nowhere* which effectively becomes the omnipotent view to *everywhere*. The view that the authors seek to challenge.

Mobility raises some interesting questions for education and schooling. In so many ways, we exist in an educational era of *nowhere* and *everywhere*. Our curriculum documents seem to arrive bearing little trace of their geographical, material or cultural origins. Mass produced text books and worksheets now increasingly shape teaching practices. And dominant policies refer to children never being left behind, although who these children are, or what they are being left behind from, is far from clear. Indeed, the word *education* itself has an unnerving generalness, devoiced from a sense of temporality and context. It is

² Building on the mystery of the unmanned and apparently abandoned brigantine merchant ship, the Mary Celeste, this metaphor serves to accent the mystery of the mobility of science, and how it drifts effortlessly intact across social and cultural boundaries with the specificities of its origins lost. Anderson and Adams (2008) reference work in anthropology that studies the movement of capitalism using similar nautical metaphors—see Ortner (1984). The ship is sometimes referred to as the Marie Celeste rather than the Mary Celeste. This confusion might have its origins in a Sir Arthur Conan Doyle novel and Sherlock Holmes detective mystery that refer to the Marie Celeste.

almost as though we have to keep pinching ourselves to remember that we live and work in unique contexts—that our practices comprise particular schools and classrooms full of unique learners. The point is that Mary Celeste’s voyage is not simply about science. To return to Latour, we should ask the question—why are our educational practices the same in Gabon and England? As scholars of comparative education bring to our attention schools are strangely similar the world over, with actually very few exceptions (Farrell 2004).

Much like the question of TEK in science education, such critical considerations must not be reduced to mere questions of logical efficiencies and epistemologies. Critical theorists would likely relish opportunities of explaining how existing structures serve those in power, who see no reason in upsetting the pedagogical and epistemological traditions of their authority. Schooling, of course, is implicated in propping up the natural order of things and as a gateway subject (along with mathematics and literacy) our practices are sharpened to include and exclude. The question of TEK as science education is, in part, about upsetting this appletart, and cannot, in so many ways, be confined solely to curriculum additions. It opens up questions at the heart of schooling itself; questions that might be traced back to Plato and the Republic, and a school established on the outskirts of Athens, in which students studied privileged kinds of knowledge showing the truth about things both nowhere but everywhere.

To fast forward to contemporary educational trends, being-in-place based environmental education was in part a reaction to inadequate omnipotent science education. Along these lines philosopher, Anthony Weston’s (2004) call for deschooling environmental education is intriguing as he says teachers must “experience the human/other-than-human boundary as more permeable than our culture teaches us it is” (p. 45). Now indigenous knowledges have known and practiced this respect for permeability for a very long time. Traditional Ecological Knowledge, as the authors note, is difficult to define and has been devalued in comparison to Science in much the same way as natural history.

... natural history can convince us that the earth is worth salvation but it is too intricate, too personal, and too impractical to provide us with the tools necessary to save it. This is the work of science. (Peters 1980, p. 202)

There has been a recent call for a revival of natural history knowledge, as it appears to have become endangered. In his research on multiple intelligences, Howard Gardner (1999) added *naturalist intelligence*—expertise in the recognition and classification of local flora and fauna—as an invaluable form of learning. Specific pattern recognition is a vital skill for any person to hone, and the elaboration and comparison of patterns is foundational to discovery processes in science (Craig Loehle 1994), and to the talents of poets, artists, farmers, and cooks (Gardner 1999). These *naturalist* qualities of curiosity and attentiveness to life patterns should be actively encouraged in all citizens. In the sciences, Edward O. Wilson (2000) argues that biological conservation and community ecology desperately need students of natural history. TEK is a huge repository for natural history teachings that exist, thrive in some places, and are actively passed on inter-generationally. Given that science hasn’t entirely *saved* us, what are we missing by ignoring and ultimately losing vast quantities of natural history knowledge and consequently the material beings?

Acts of subversion in science education

So, how might we subvert the global rhetoric of Science? From his prison cell in Turin, in 1929, Antonio Gramsci wrote to his wife about his concerns regarding his son’s obsession

with playing with Meccano.³ It has a tendency, he wrote, to make “man rather dry, machine-like and bureaucratic” (Gramsci 1988, p. 88). He then continued with comments about the dangers of educational principles that determine the *new* and lamenting his son’s seeming *obsession*, almost *intoxication*, with science, technology and mathematics. In contemporary times this seems so delightfully quaint. While things have certainly changed dramatically since Gramsci’s day, such personalised reflections serve to locate science and technology education within the historically emerging concept of hegemony itself, which is a pause for thought.

van Eijck and Roth set their article within discussions of Foucaultian *regimes of truth* and the power structures of society. As they note these arguments extend far beyond the prison to include schools and the minute power relations that constitute our lives. The danger here is that after reading Foucault, regimes seem so entrenched and robust. But the exercise of power, as Foucault (1977) himself comments, always goes hand in hand with resistance. And throughout both papers there is an undercurrent that TEK as science education raises significant opportunities for resistance. Such possibilities stem beyond free-floating oppositional narratives to narratives that might exploit some deep-rooted contradictions in current realities. Edward Said (1993) claims that postcolonial perspectives offer a view from within, called *counter-narratives* that disrupt and transform the official natural histories, and could question some of the reigning truths in science education. For post-colonial scholar Ilan Kapoor (2003, pp. 566–567), referring to Homi Bhabha’s work, however, “there are no relations of power without agency” and power is concerned with “making possible and making trouble, both at once.” Perhaps the key question here is what can we trouble in science pedagogy from this standpoint?

The environmental activist Starhawk (1987) is always direct. We must become more than victims, she writes, by “actively resisting weapons that culture has devised against the self” (p. 71). To resist we have some choices; to comply, to rebel, to withdraw and/or to manipulate. The authors of the preceding papers seek in many ways to *manipulate* dominant discourses and practices. These acts of subversion, we suggest, have different referents. They force us to ask how our research and practice might become more strategic in seeking out transformations that we desire. In the following sections we explore three acts that TEKs provoke.

Act I: Localism

van Eijck and Roth’s arguments, as their title suggests, are in part built on keeping the “local local.” They explore the knowledge applied to salmon fishing practices of Coast Salish peoples at the Northern Pacific coasts of Canada and the United States. The choice of location, in this regard, is not arbitrary. It is a specific cultural and ecological location to compare and contrast common linguistic and physical artefacts of WSÁNEĆ (Saanich) people with those of scientists (an evolutionary biologist). As you read their case what becomes clearly apparent is that location matters in epistemology and pedagogy. This point is all too easy to overlook in an era of globalisation and transient *liquid modernity* to use Zygmunt Bauman’s (2008) term. Science and technology seem so naturally universal and globalised but what emerges in van Eijck and Roth’s case study is the power of location. Uncovered in the particular are the experiential situations of knowledge production and use

³ Meccano is a brand name of a popular metal construction system. The first sets were developed and sold in the UK during the early 1900s. It is still very popular, particularly in Europe I suspect. Indeed, as a child I (Alsop) shared Delio Gramsci’s obsession. As a child, I (Fawcett) caught snakes in the backyard instead.

and this is where global power differentials can subside. There is subversion in the pedagogical act of keeping the local local.

Whether or not (and how) place matters in science, education, and science education has been long debated. In *Science and Technology Studies*, Christopher Henke and Thomas Gieryn (2008) eloquently describe meta-studies of science and technology in terms of four historical waves. The first wave is the analytical analysis of the scientific method by philosophers such as Karl Popper and Imre Lakatos, which served, they suggest, to effectively “rub out geographical differences” (p. 354), effectively supporting the view from nowhere. The second wave (starting in the late 1970s) involved ethnographic studies of laboratories by sociologists and anthropologists (including Harry Collins, Bruno Latour, Steve Woolger, Karin Knorr Cetina and Michael Lynch and many other names that will be familiar to readers of this journal) that showed how scientists excise circumstantial modalities from their texts. This work largely focused on documenting the loss of the laboratory, rather than uncovering particular laboratories per se. In the third, much more recent wave, researchers reveal how different epistemic regimes are enacted through inquiries, and in the fourth wave, Actor Network Theory, our attention is brought to the more-than-human materialities that hold a central role in the productions of knowledge.

The point that Henke and Gieryn (2008) make is that recent waves of contemporary scholarship in studies of science have increasingly focused on mobility and fluidity of knowledges and actants in networks, rather than the actual places as starting and end points for knowledge. A new wave of scholarship they advocate is to pay closer theoretical inspection to specific geographical locations and situated materialities.

The epistemic power of van Eijck and Roth’s pedagogy is, in part, built on the ways in which this case’s location brings into sharp relief differences between local and transitory knowledge claims. The juxtaposition of WSÁNEĆ knowledge and evolutionary biology is a juxtaposition of knowledge that coincides with the place of experience and knowledge in which associations between experience and place have become severed. The act of severing serves to prop up universalised hegemonic claims. The upshot is that once transitory knowledges become localised they can become contestable and more vulnerable. This is not to say that sciences do not bring insight and explanatory power to the locations in question, but it is to say that the authority of other valuable local experiences can now become visible. On this point, there are now numerous examples of studies of traditional, neo-traditional and local knowledges that demonstrate how actors can become empowered through both geography and ecology. The central point here is that epistemic and pedagogical emplacement creates opportunities to subvert cultural authority. The situatedness of pedagogy within distinctive, local discrete geographical and culturally rich locations creates ways to push back forces that serve to marginalise some knowledges and pedagogical practices.

Of late, there has been much interest in what has been called the *new localism* in education. Place-based-education has a series of high profile advocates (e.g., David Gruenewald and Gregory Smith 2008). In a general sense these approaches adopt local environments—social, cultural, economic, political and natural. But there are caveats here and it is important not to be drawn into celebratory hierarchical enactments of old dualisms—nature versus culture, localism versus globalism, rural versus urban, traditional versus non-traditional. Localism offers many interesting possibilities for science education which as the previous discussions suggest include hopes of resisting and challenging globalised knowledges and imperialist cultures. However, bounded places have their limitations and associated discourses can not overlook inequalities and boundaries inscribed in the local. It is an open question of when the local becomes parochial (for

example)? In proposing a radical pedagogy of place, Claudia Ruitenberg (2005) critically examines the concept of locality in place-based educational practices and the trap of *topological essentialism* that resides in deterministic notions of locality and unquestioned desirability of rootedness. Local places are not necessary the conditions to develop *better* identities, *better* pedagogies, *better* epistemologies and *better* societies. Moreover, there is no localism that is not connected and uncontaminated by globality—after all, in fundamental sense, the local is only intelligible with reference to the existence of the non-local which, as such, always leaves its imprint. We should be ever careful of not stumbling back into romantic myths of isolation and overlook interdependencies, relationships and the trans-local.

Act II: Utilitarianism

John Dewey's (1938, p. 17) response to “either-ors was that they were alright in theory but when it comes to practical matters circumstances they compel us to compromise.” van Eijck and Roth's case study is also a story of “practical matters” and the virtues of increased agency. To question existing regimes of truth, these authors suggest, we should experience the differing efficacy of simultaneous but different forms of human knowledges within contexts of shared concerns and desired action. Phrased differently, a way to de-privilege Science in science education (using our terms) is within a pedagogy of agency set within a specific social and environmental context.

The judgement of knowledge through better social and environmental outcomes is haunted by Benthanist utilitarian overtones.⁴ In comparing and quantifying knowledges van Eijck and Roth direct us toward instrumental worth in practical situations. In the context of the case study this has documented merits as we get to experience that science, to use the authors' words, “is not all that glitters.” But, such an approach is not quite as straightforward as the authors imply. Mueller and Tippins rejoinder brings our attention to the measurement problem. What is the greatest good? In the quantification of such complex things there is always an inherent danger of substituting desires and hopes with what is easily measureable and *objective*. Furthermore, there are also clear competitive overtones here, which serve unless careful to reinstate old dichotomies of theory versus practice, and academic versus applied. We should not draw from van Eijck and Roth's case study that we should seek pedagogical situations in which sciences and TEK battle things out and prove their superior utilitarian worthiness. To assume that what is one's gain is the others' loss is to return once more to either/or dualisms. However, this is not the same as questioning the false glitter of Science.

High status knowledges draw cultural authority from institutions (whether they are institutions of science or institutions of schooling) that promulgate knowledges separated from the immediate motives of practical life. Such institutions see themselves as specifically standing for the value of knowledge pursued for other than practical effectiveness (Immanuel Kant 1979 [1795]). The proposition that van Eijck and Roth raise is that “practical matters” and “performance” can serve to unsettle existing spectator models of epistemic and pedagogical authority. Although such a position opens up a series of questions we should not become drawn into abandoning the prospects that this approach might bring. Utilitarianism is an ideal; it will always be a project to become and as such

⁴ Although it bears no immediate relevance for these discussions, I (Alsop) had the unusual situation of seeing Jeremy Bentham every day while at University. He is preserved in a cabinet at University College London and used to be on display between the Physics department and a university coffee shop.

involves simultaneously grappling with associated tensions. To abandon utilitarian aspirations because of empirical ambiguities seems in colloquial terms to put the *horse before the cart*. What concerns us more is the ever present tension in school based reforms of everything becoming so eminently measurable, quantifiable and seemingly *apolitical* that it loses sight of broader questions of purpose.

The science/TEK pedagogy that we seek looks outward into the world and inward to the needs, hopes, possibilities and dreams of change. We are hopeful in re-envisioning sciences educations⁵ in relation to global (but not globalised), local (but not parochial), and personal (but not individualistic) contexts and commitments. Collective, collaborative actions always matter. Such commitments elucidate a shared hope that knowing well and doing well can be entwined, folded into pedagogy that is much more than covering *knowledge*. This is not to sidestep the tensions of empiricism, but to grasp tightly to the overwhelming educational merits in dialectics and dialogics between learning well and acting wisely. To use Latour's (2004) distinction we must be ever conscious of not letting slip *matters of fact* from *matters of concern*. However, we remain cognisant that *knowing and doing* is very different to *knowing well and doing well* and with this shift our conversations are no longer about pluralistic explanatory claims but now constitute morals and ethics.

Here we concur with Maxine Greene (1995) that in education we must explicitly seek opportunities for bringing into being of norm-governed situations in "which students discover what it is to experience a sense of obligation and responsibility, whether they derive that sense from their own experiences or caring and being cared for or from their intuitions and conceptions of justice and equity" (p. 66). For us the question of TEK in science education is, in part, to expand our ideas of an ethics based science education (see David Blades 2006). As Hans Jonas (1982) discussed in his philosophy of aliveness, only Life can know Life. It is these assemblages of *naturecultures* as Donna Haraway calls them, that we believe should guide us in approaching and thinking about a science pedagogy "where the categorical separation of nature and culture is already a kind of violence, an inherited violence anyway" (2000, p. 106).

Similarly, Jim Cheney and Anthony Weston (1999) resist the reigning epistemology-based ethics, where ethical action is usually in strict response to *knowledge first*, as opposed to approaching knowledge making with certain etiquettes of humility and vulnerability from the first encounter. They are in favour of developing an environmental ethics-based epistemology, where ethical action is first and predominately a way to enrich the world and create more possibilities for deeper knowing. Cheney and Weston (1999) distinguish an ethics-based epistemology on the grounds that: (a) the world is neither easily nor simply knowable; (b) ethics is not extensionist and incremental, but pluralistic and dissonant; and (c) because hidden possibilities surround us the task of ethics is to call them out, illuminate, and improve the world. And feminist moral philosopher, Lorraine Code (1995) brilliantly critiques objectifying practices that are *epistemically irresponsible*, bring harm to others and are ethically barren.

As scientists and educators interested in lived, co-constructed interactions with nature, we have been educated by (eco) feminist inquiry, science studies (especially actor-network theory) and phenomenological thinking. Each offer different perspectives but what they have in common is a resistance to eco-managerial and eco-centric types of human relationships to nature, and solidarity with a social-nature approach which allows for the blurring of the boundaries between nature and humanity (Noel Castree 2001). Science

⁵ Here we use plurals to emphasise the pluralistic natures of epistemologies and pedagogies.

studies scholar, Bruno Latour (1993) has luminously shown how the proliferation of hybrids of politics, science, technology and economy can be understood through actor-network theory, where networks are “simultaneously real, like nature, narrated like discourse, and collective, like society?” (p. 6). Actor Network Theory (ANT) has given us many intellectual gifts including: (a) examples of translation and purification processes that sever humans and culture from non-humans and nature (Michael Callon 1986); (b) clear acknowledgement of how we “tend to perform dualisms” particularly through language; and that that there are “multiform kinds of agency” (Michael Callon and John Law 1995, p. 486 and p. 503); and c) political hope as the relations of power that construct social natures are made visible (Bruce Braun and Noel Castree 1998).

The pedagogy that van Eijck and Roth’s advocate also holds considerable hope and promise for community. The idea is pedagogy emerges within groups with shared concerns acting democratically by sharing knowledges and experiences. In this respect, they join with a very large number of contemporary scholars advocating *community-based-education*. But too often, perhaps, as Ruitenberg (2005) notes, in such discussions community is taken as self evident and essentially desirable. Communities are not universally *good*, they are themselves riddled with power asymmetries and injustices. Indeed, when Jacques Derrida (1976) used the word community he accompanied it with a series of caveats, as Ruitenberg (2005) notes. This is not to reject the aspiration to the ideal community but in recognition that there is no community, entirely unspoilt.

Act III: Principled Diversity

Given that we are experiencing a dramatic, devastating, loss of cultural diversity, how should we act? Language is often used as an indicator of this loss (some estimates suggest that 4,000 of the 7,000 languages spoken today not being passed on to children). As Wade Davis (2009) reminds us, this not simply a question of syntax:

A language, of course, is not merely a set of grammatical rules or a vocabulary. It is a flash of the human spirit, the vehicle by which the soul of each particular culture comes into the material world. Every language is an old-growth forest of the mind, a watershed of thought, an ecosystem of spiritual possibilities. (p. 3)

How should science education respond to such cultural loss? Mueller and Tippins focus our attention on the importance of principled diversity; that the overriding factor in determining the content of science education should be a *principle*. Inclusion of TEK, they persuasively argue, should not be left to external consequences of utility and localism, but there are times when we need to judge cultural loss as something that is wrong in principle and act accordingly. We fully support this position. There is a real urgency here and principled changes can ensure mobilisation in educational systems that are often rather slow to respond. The science education that we seek aims toward a community that accepts that it shares its imaginaries with others and articulates these imaginaries as part of constituting a shared world and practices of living in this world. In support of such a position, science education, at the very least, needs to be comprised of divergent discourses. As Mueller and Tippins note such a position not only enlarges conceptual and agential windows but also much evidence suggests serves to encourage marginalised cultures to enter science education (Council of Ministers of Education Canada 2002).

This is not an argument, however, for multiculturalism as pluralistic incommensurability; separate epistemic and cultural tracks. And we must remain cognisant that some relationships are more desirable and digestible than others. Such deliberation seem to steer

toward the efficacious manifestations of cohabitation, collaboration, collectivism and many other expressions of hybridity (integration, synergisms, and creolization) all of which have been expressed in recent post-colonial discussions.⁶ Mueller and Tippins use Thayer-Bacon's "both/and logic that helps us recognise our differences while valuing and respecting others, and while acknowledging our commonalities and interconnectedness with other people and the Earth's ecosystems." The arguments of pluralism with humility it seems have much to offer.

We continue to be inspired by Sandra Harding's (2008) *Sciences from below*; the multiple ways that feminist and postcolonial studies contribute to further epistemological pluralism. Nevertheless, we must remain cognisant of increasing difference becoming mapped onto underlying power differentials. Farquhar Cohen (1994) offers a powerful critique of Hardings' work in this regard. The myth of Science serves to marginalise other knowledge, and acknowledging TEK as science in science education involves redrawing the boundaries of epistemic purity. This is more than simple curriculum co-habitation. It means having to reframe our focus on the political aspects of those relational spaces we engage in our classrooms. Unlike the ontology of diversity focus, epistemic plurality involves creating spaces where the uniqueness and asymmetrical reciprocity of narratives are put into sharper relief. There has been so much to celebrate in instructional strategies that help learners to negotiate borders between Western Modern Science and indigenous science. However, "pedagogical stepping stones" (Gloria Snively and John Corsiglia 2001, p. 7) must also embrace opportunities of thinking critically and exploiting pluralistic epistemological commitments, contradictions and imbalances. We need to shape practices in which knowledge traditions can be compared and discussed without privileging any of them epistemologically. Location is, again, an obvious choice here because even the seemingly most globalised science, like any other practice, has a local story. While, no doubt, epistemological pluralism opens up conversations and possibilities, the shadow side wonders when is "the 'equality' of positioning a denial of responsibility and critical enquiry" (Haraway 1991, p. 191)?

Discussion

So what science education do we need? Imbedded within all responses are referent points; should we view practices as expressions of things that are, or things that ought to be? On this point, we share Nancy Brickhouse and Julie Kittleson (2006) vision of science education as a way of advancing the sciences that we need rather than those we presently have. There are many reasons for including TEK in science education. Indigenous students continue to be marginalised in science education on the basis of cultural identities (Marie Battiste 2002); TEKs embody environmental awareness and ecological responsibility (Snively and Corsiglia 2001); epistemic monocultures are likely to be less flexible and more sterile; there are also important economic and vocational arguments regarding future STEM agendas (as Mueller and Tippins note).

⁶ For a helpful review of postcolonial studies of science education see Anderson and Adams (2008). Ilan Kapoor's (2008) text, *The postcolonial politics of development* (London: Routledge) and John Willinsky's (1998) text *Learning to divide the world: Education at Empire's end* (London: University of Minnesota Press) offer detailed and assessable discussion of education and post-colonialism and development and post-colonialism respectively.

In this article we have explored the question of TEK as science education in largely epistemological status terms. We have sought to explore science education in terms of subverting dominant forms of cultural authority: How does TEK as science education help to make visible and confront hierarchies assumed within our practices? We have discussed absence of location, unity and multicultural principles in science education and schooling which serve in their own ways to establish and maintain hierarchies. However, the exercise of power as Foucault reminds us, goes hand-in-hand with resistance and as the preceding discussions suggest localism, utilitarianism and principled diversity offer important ways of challenging the cultural authority of Science in science education. TEK as science education, it seems, offers multiple opportunities to challenge the status of Science, and disrupt *natural* educational orders.

We highlighted a difference of opinion in the original articles regarding recalibration. van Eijck and Roth's original article sought to recalibrate the status of Science and TEKs in education because they framed these knowledges as culturally and materially incommensurate. Such recalibration they argue is possible on utilitarian grounds. In contrast, Mueller and Tippins argue that recalibration is unnecessary as TEK and science are not mutually exclusive and an enlarged system of TEK and science is likely to bring about the equality that is required. We have expressed our reservations with *hard* statements of incommensurability as through either/or type logic these can misrepresent complex epistemological and cultural relationships and might shrink imaginaries. Moreover, such dichotomies carry the possibilities of becoming re-enacted as demarcations of superior-inferior relationships. However, we join with van Eijck and Roth in celebrating the epistemic possibilities and hopes of a pedagogy of localism and utilitarianism, and the powerful opportunities that this can provide in subverting the universal truth claims of Science. We also join with Mueller and Tippins to recognise the importance of principles as a way of ensuring diversity within science education curricula and celebrate curricula that have already adopted this approach around the world. But the question remains, should the status of TEK and science be recalibrated in science education? In response, we suggest that the dissociation of Science from the sciences is helpful. It is fruitful, we suggest, to dissociate the cultural, local, discursive, material practices that constitute TEKs and sciences from the rhetoric of Science. We agree that TEK and science are not (and should not be) framed as mutually exclusive practices. Moreover, these practices, we suggest, should share concerns about how Science distorts knowledge claims. In this respect, they have a shared *negative solidarity* using Hannah Arendt's (1954) terms. We also agree with the sentiment of Mueller and Tippins claim that science is TEK and TEK is science, however, we fold in the caveat that the sciences should seek to separate themselves from Science. Thus, the recalibration that we seek in science education is to confiscate the threat that Science brings, and as the preceding discussions suggest TEK offers science education opportunities to confront Science through choice of location, utility and principle. To re-imagine the teaching of science is to remember "the joining of partial views and halting voices into a collective subject position that promises a vision of the means of ongoing finite embodiment, of living within limits and contradictions, i.e. of views from somewhere" (Haraway 1991, p. 196).

After this nothing happened

We now return to Plenty Coup and his story of lives entwined with dwindling buffalo herds, specific lands, and cultural vulnerabilities. In this essay we sought to explore the

question and hopes of TEK as sciences education as a challenge to the cultural authority of Science. Throughout these discussions there has always been the open question as to what has been keeping TEK and science education apart? What might we have been missing to change the way that things have turned out? Has it been a lack of humility? Lack of creativity? Lack of power? Or, perhaps, something else? Jonathan Lear's inquiry into the Plenty Coup story forces us to contend with a point after which cultural experiences become undone and might be the source of undoing. Our opening paragraph concludes with a series of questions: What might it mean to imagine science education as a site of such vulnerability, fragility and potential transformation? How ought science and science education live with the very possibility of their own demise? We now turn to these questions to frame a concluding twist. One subtext of the preceding discussions has been a commentary on certainty. We start by troubling bifurcations of multiculturalism and universalism as statements of certainty, and brought attention to the weaknesses of dualisms and the inherent merits of partial truths. Throughout these discussions we have sought to muster our creative and logical energies in challenging the mythical certainties of Science as universal, absolute truth. In response, our arguments have sought solutions by making sense of TEK and science in logical, material and cultural terms and in so doing seeking to dissolve established debilitating hierarchies. We have established the position that different knowledges exist and they are supported by different cultural, environmental and material claims.

But, what if we interpret the question of TEK as science education as less about settling questions of the past (and present) and more about helping us confront and tolerate the disillusionment of knowledge and education to give us the answers that we desire. Is there merit in exploring this question as a site of deep conflict and vulnerability which unsettles and disrupts our desires for certainty? What would it mean to entertain the idea that science education has to tolerate not only the loss of certainty in knowledge but also a loss in certitude in the processes of pedagogy and learning themselves? Jonathan Lear's reading of Plenty Coup, we posit, is an invitation to recognise our vulnerability. It presents us with opportunities to think again about epistemological certitude and how epistemology and pedagogy are themselves often implicit acts of certainty. It provokes us to consider processes of learning science as resisting closure and thinking about what happens when meaning cannot be made certain.

In our dominant institutional practices of schooling there is an ever present danger of re-enacting the very conditions of power which served to radically exclude knowledges in the first place. Schools in so many ways are set up to promulgate Science. The point is that TEK as science education cannot be reduced simply to epistemological solutions in education (and schooling) because the very notion of solutions serves to prop up certitude that we have previously sought to question. In this regard, we must consciously avoid our practices becoming enveloped by the promises of knowledge but simultaneously hold onto an abandonment of the possibilities of representing truth. To phrase this slightly differently, pedagogy must not emerge as predetermined outcomes, because this approach once more reinforces the certitudes that serve to separate different knowledge claims.

Lear's study of Plenty Coup teaches us about cultural vulnerability, it forces us to unsettle and overcome desires for normative closures in science and science pedagogy. And if science education is to be a significant intervention into the complexities of knowledge and actions it should not be solely reduced to rational explanations to resolve epistemic conflicts. The work of becoming a subject as an encounter with multifarious scientific knowledges is at its heart the ability to tolerate and narrate the disillusionment and possibilities of encountering the otherness, the dualisms, that sciences (that include

TEKs) provoke. As Lisa Farley (2009, p. 550) writes, “when we emphasise the promise of reason and progress through education, what is forgotten is its underside: the conflicts, passions, anxieties and uncertainties that fuel questions in the first place.” Lear’s account of Plenty Coup builds towards a complex and lived notion of radical hope (too much to discuss in this paper) but it gestures towards the praxis of creative decision-making in radically different historical contexts, learning beyond collective shame for past mistakes and courageously agreeing to try anew. Recalibrating science and pedagogy, in the project of science education, at its heart requires, amongst many things, courage and vulnerability. Our hope is to explore this position in future publications.

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