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FORUM

[Re]considering queer theories and science education

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Abstract We take Mattias Lundin's *Inviting queer ideas into the science classroom: studying sexual education from a queer perspective* as a point of departure to explore some enduring issues related to the use of queer theories to interrogate science education and its practices. We consider the uneasy, polygamous relationship between gay and lesbian studies and queer theories; the border surveillance that characterizes so much of science [education]; the alluring call of binaries and binary thinking; the 'all' within the catchcry 'science for all'; and the need to better engage the fullness of science and the curriculum, in addition to noting silences around diverse sexes, sexualities, and desires. We catalogue some of the challenges that persist in this work, and offer thoughts about how to work with and against them to enact a more just and compelling science education.

Keywords Science education · Queer theory · Heteronormativity · Sexuality · Inclusion

> These identifications I take as the beginnings of a queer pedagogy, one that refuses normal practices and practices of normalcy, one that begins with an ethical concern for one's own reading practices, one that is interested in exploring what one cannot bear to know, and one interested in the imagining of a sociality unhinged from the dominant conceptual order. (Britzman 1995, p. 165)

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This paper responds to issues raised in Mattias Lundin's Inviting queer ideas into the science classroom: studying sexual education from a queer perspective. doi:10.1007/s11422-013-9564-x.

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Mattias Lundin's paper (this issue) provides a timely and informative jumping-off point for a [re]consideration of the small body of work over the past 15 years examining the encounters and intersections of science education and queer theories. The paper incites rich conversations and questions, a few of which we elaborate in what follows. It instructively reminds us of several key issues that warrant disentanglement, and it is faced with many of the challenges that bedevil similar work. In this paper, we will attempt to unravel and canvass some of the issues at the heart of bringing queer theories to bear on science education, and we will sketch out our responses to some of the challenges that persist in the field.

The issues we raise are aligned with, but we think move beyond, Francis Broadway's (2011) characterization of three important conceptual elements of such an undertaking, namely "explicating science education as a queer curriculum; elucidating science education as a form of pedagogy, specifically a queer pedagogy; and exposing science as being" (p. 295). While we find this theoretical trinity useful, we explore additional issues that we think occupy the interstices of these conceptual fields. We intentionally disentangle these issues to examine them one by one, realizing of course that they don't exist and play out as isolated and separate, and that they will indeed congeal back into polyvalent assemblages in which they manifest in practice. We will characterize some of the challenges that we feel have haunted the work of queer approaches to and critiques of science education and, while acknowledging that not all are surmountable, we offer some thoughts about how those challenges might be engaged and addressed.

It's either binaries or it's not: gay and lesbian studies versus/and queer theories

> The pedagogy at work is one where the desire for knowledge interferes with the repetition of both heterosexual and lesbian/gay normalization (Luhmann 1998, p. 141).

Queer theories insist on deconstructing binaries like heterosexual/homosexual, straight/gay, female/male, woman/man, and masculine/feminine in master narratives that position heterosexuality as normal and natural (Sullivan 2003). Dismantling heteronormative binaries undermines identities that rest upon binary oppositions. And so queer theories and those who work with them soon find themselves caught up in binary thinking about binaries, contrasting queer theories and their deconstruction of fixed identities with the identity politics of gay and lesbian studies that speaks up for individuals and groups that are disregarded and silenced by heteronormativity. It seems that our relationships with binaries must be ambivalent and ambiguous, rather than casting them as simply good or bad. Lundin's paper reminds us about the simultaneous affordances and limitations of binaries and binary thinking.

Lundin writes that he wants to foster education that "attracts and relates to all students" by using queer theories to develop "critical perspective[s] on the heterosexual norm." Queering is paradoxically alluring and irritating to those of us who want to deconstruct normalizations around sexes, sexualities, genders and desires, while holding to liberal social justice norms like inclusion and equity that rely on tidy identity categories that are enabled by the very normalizations we are trying to move beyond. Lundin is tangled-up in this mess, but he isn't alone. We can gain some perspective on the predicament by looking more closely at how queering is related to the politics of identity that is often (but by no means always) associated with gay and lesbian studies.

Dennis Carlson (1998) offers a helpful account that we follow here of the relations of gay and lesbian identity politics and queer theories. Gay and lesbian movements, like civil rights and women's movements before them, have used identity politics to counter histories of being stereotyped, pathologized, and silenced. Identity politics pursues recognition, renaming, and re-representation for people who claim shared histories, cultures, and concerns that have been denied voice and self-representation in dominant cultures. The power of identity politics to advance certain kinds of social change is undeniable. Unfortunately, identity politics easily slides into essentialism and fundamentalism that, for instance, root the historical, material, and embodied sociocultural phenomenon we call 'being gay' in genetics (Allen 1997). Equity and inclusion projects pursued from within identity politics take up identity categories, and in so doing they may import essentialism that reduces the self to normalized and naturalized identities.

While identity politics proclaims ontologies of being(s), queer theories deconstruct identities by tracing social epistemologies and phenomenologies (Ahmed 2006). Now, rather than taking that facile dichotomy for granted, we will proceed with attention to Susan Talburt's (2000) insight that queer theories are constitutively haunted by identity. Queer(ing) carries identity in several guises: as a "denunciative heterosexualizing" (Honeychurch 1996, p. 340) slur; as a paradoxically repurposed identity label claimed by queer activists; and as a synonym for gays, lesbians, non-heterosexuals, and even naughty and otherwise non-conforming heterosexuals (Halperin 1995). Even as a verb, 'queering' leaves the residue of *being* queer, just as tending a garden suggests you are a gardener. To make our way through the world we take up and are pressed into subject positions. And so in our queering efforts to undermine normalized identities, we fluidly take on and/or are ascribed identities as those who are trying to undermine notions of inherent, immutable identities. Queer(ing) does not seek an end to identifications [in fact, Susanne Luhmann (1998, p. 151) calls for the "infinite proliferation of new identifications"!], but for a stance toward identities as contingent, contested, storied, and impermanent, even fleeting, effects, not inborn essences (although identity may be cast as essence in identity stories). Queering advocates an intentional stance toward paying attention to how we relate to subject positions; how we hold, refuse, confuse, and reuse them; and whether we attach self to its identities or attempt to hold identities loosely and skillfully in embodied awareness as stories that serve and ensnare (Loy 2010).

Against gay and straight norms that hold identities as the causes of who we are, queer theories are "deeply suspicious of all identity categories" (Carlson 1998, p. 113). As Annamarie Jagose notes,

> Broadly speaking, queer describes those gestures or analytical models which dramatise incoherencies in the allegedly stable relations between chromosomal sex, gender, and sexual desire. Resisting that model of stability—which claims heterosexuality as its origin, when it is more properly its effect—queer focuses on mismatches between sex, gender and desire….[Q]ueer locates and exploits the incoherencies in those three terms which stabilise heterosexuality. Demonstrating the impossibility of any 'natural' sexuality, it calls into question even such apparently unproblematic terms as 'man' and 'woman.' (1996, p. 3)

Queer theories trace identity work and the making of selves through power relations, storying, improvised performances of multiple selves, and the subconscious dynamics of the psyche. If identity politics soothes existential angst, queer theories construe (and celebrate) personhood as "a contradictory and complex phenomenon" (Morris 2000, p. 15). There is little here on which to hang equity and inclusion projects as they are normally conceived.

So we wonder what Lundin has in mind for queer perspectives. In his paper, Lundin notes instances when hetero norms are enforced, as well as occasions that could be used to challenge hetero norms by opening spaces for other ways of knowing and being. If this is as far as it goes, identity politics may be up to the task. In the US and elsewhere, recent advances in civil rights for gays and lesbians have proceeded by normalizing a proximal segment of the Other, admitting it to a modestly revised version of the hetero norm. "The norm and its negated other" writes Luhmann, "are implicated and mutually constitutive of each other" (1998, p. 151). The co-constitutive nature of the normal and abnormal—which positions homosexuality as the "indispensible interior exclusion" (Fuss 1991, p. 3) of heterosexuality—gives non-heterosexual identities a foot in the door, so to speak. Because "non-straight sexualities are simultaneously marginal and central" (Luhmann 1998, p. 144), to marginalize the Other, heteronormativity must hold it close. The hetero norm and the Other move into and through each other in an intimate embrace.

Pathologized interior exclusions remain necessary co-constituents of a liberalized hetero norm, and plenty of sexual and gender minorities, as fantasized via the hetero norm, remain to fill this role. In the meantime, segments of gay and lesbian populations (including the authors of this article) who are, accurately or not, perceived to share the educational, socioeconomic, ethnic/'racial', and familial values of the hetero majority increasingly enjoy the fruits of being regarded as (more-or-less) normal in relation to their straight compatriots. We suggest that, as in broader society, it is primarily by this path that ways of being and knowing previously excluded and silenced by the hetero norm have to some modest extent begun to make their way into certain curricula and classrooms. If by challenging norms to advance equity and inclusion, Lundin intends to include more ways of being and knowing within a modestly refigured hetero norm, then an assimilationist path may address his concerns, without taking on the complexities and contradictions of queer theories. But we hope Lundin has something more complex and contradictory mind.

Queering (school) science?

Queering personal identities that circulate in/as classroom cultures is one thing, but what would it mean to queer science? To begin, we might note where the honorific term 'science' is claimed and conferred, refused and withheld. We should wonder about the grounds for these distinctions and the ways in which the apparent presence and absence of so called science, non-science, pseudoscience, etc. are co-constitutive, with silences in presence and presence in silences. Lundin notes that he selected for analysis "situations that question the [hetero] norm or seem to establish the norm," and that "biological content is far from evident in the presented examples." He draws a distinction between "relational issues" (that concern how students and teachers relate to and know one another) and "biological content," and suggests that in the selected vignettes teachers emphasized the former. These relational issues perhaps reflect the larger category of "moral[ity] and ethics" that at the beginning of the paper Lundin suggests can and should be considered along with the fact-based content of science education. We read Lundin as holding relational issues separate from science content, perhaps for the sake of analytical clarity. But we wonder if there is a more fundamental ontological distinction at work in his thinking, such that relational issues and biological content are threads that maintain their distinctiveness from one another even when interwoven. By assuming a distinction between moral/ethical concerns and biological content, and focusing on episodes rich in relational issues (because that's where heteronormativity seemed most evidence), Lundin leaves

himself with few opportunities to investigate the reciprocally constitutive relations of morals/ethics and science content, and to explore how heteronormativity manifests in the core of science content, as he notes others (Letts 2001a) have argued it does.

Even so we think the examples in Lundin's paper offer glimpses of biology content in drag as heteronormative relational issues. Instead of holding relational issues apart from biological content, imagine that relational issues are laden with biological meanings that circulate in/as classroom and broader cultures, and that biological content is necessarily laden with relational issues around its production and interpretation in/as culture. The students we meet in Lundin's episodes draw on evocative vocabulary—dickhole, muscle sausage, bang cover, wet cave. While these terms can be heard as heteronormative slang, classified as undesirable and 'ugly' by the teacher, as is the way with heteronormativity, they also invite transgressive thoughts that paradoxically work against the originary heteronormativity of the terms. Our point is that there is more at stake in these terms than heteronormativity. "Wet cave" is unlikely to be on the vocabulary list in the Swedish sexuality education curriculum, but the various structures and functions that the term evokes are legitimate curricular content. When transgressively privileged as biological content knowledge, the language used by students does a remarkable job of capturing, in ways that conventional scientific terms do not, the reciprocal relations of structure and function, which is an important organizing principle in the sciences and technology. Recognizing and tapping into the understandings of nature and science that students bring to the classroom surely gives educators better opportunities to address the heteronormativity that inflects those understandings.

Other studies have begun to explore what it might mean to queer the content of science education. For example, when high school students titter over pronouncing terms like phagocytosis and homozygous, or protest that students of the same sex should not be paired in a classroom simulation of Mendelian inheritance, we can see the mash-up of heteronormativity in/as biological content in learners' minds and bodies (Fifield in press; Fifield and Swain 2002). These studies explore how the sense that a student teacher, Lee, made of himself as gay was shaped by and re-shaped his feelings for and understandings of the ontological and epistemological status of scientific knowledge. Lee became acutely aware that core realities of his life as a gay person were utterly absent from the biology content he had learned and was learning to teach to others. He came to believe that he could no longer trust science and the science curriculum to offer unbiased accounts of the facts of life.

Two studies of biology textbooks have made important contributions to bringing queer theories to bear on the science curriculum. Vicky Snyder and Francis Broadway (2004) examined eight widely adopted biology textbooks for their treatment of sexualities outside the heterosexual norm and found, perhaps not surprisingly, a profound silence. Just three of the eight books referred to sexuality outside the straight norm, and those three mentioned homosexuality only in relation to AIDS. These are the curricular silences around sexual diversity in relation to human genetics, behavior, and reproduction that the student teacher Lee said made him feel excluded from the biology he had learned and was learning to teach.

Snyder and Broadway conceived of queering textbooks as "pointing out the silence and absence of sexuality outside of the heterosexual norm" (p. 629). This queering of absence reflects an orientation, like that in Lundin's paper, toward bringing in outsiders who do not "'fit' into the heterosexual norm" (Snyder and Broadway 2004, p. 618). With the benefit of hindsight, and following Broadway's (2011) subsequent critique, we argue that this queering of absence manifests its own silence around the processes that normalize heterosexuality and its binary genders. A more thoroughgoing queering deconstructs the

presence of the normal as well as the absence of the Other, and resists subsuming equity and inclusion into normalizations that in the end leave the normal/Other binary in place, and continue to collapse the self into fixed identities (Carlson 1998). The point of queering is not to fit the "all" into one or more norms, but to mark, deconstruct, and pass beyond the regulatory impulse to fit being(s) into finite categories.

Jesse Bazzul and Heather Sykes (2011), the focus paper in an earlier Forum in this journal, used queer theory to analyze how a high school biology textbook that is widely used in Ontario addressed sexuality and gender. Like Snyder and Broadway (2004), Bazzul and Sykes noted the absence of any treatment of sexualities outside the heterosexual norm. They further pushed queering beyond these silences by identifying heteronormativity in discussions of behavior and hormones, and in terminology that conflated sex and gender within a heteronormative framework. In his response to Bazzul and Sykes, Jay Lemke (2011) takes science and science education to task for failing to live up to the epistemic virtues those disciplines use to claim special privilege as producers and stewards of knowledge, minds, and bodies:

> How dare a textbook or a curriculum that claims to be both scientific and educational represent as biological fact that there are only two sexes, perfectly aligned with only two genders, which are each biologically determined to be only one or the other, and biologically determined to find one another sexually attractive, whether with reproductive results or not?" (p. 288)

Lemke's call for science and science education to live up to their professed standards of objectivity affects a paradoxical queering by demanding that scientists and educators not rest comfortably in some myth of objectivity, but that they critically account for the broader cultural beliefs that necessarily empower, advance, limit, mislead, and bias scientific knowledge.

Broadway's (2011) enrichingly difficult response to Bazzul and Sykes is insistent in bringing us back to queering: to queering curriculum, pedagogy and science, and to queering queering. He's concerned that in Bazzul and Sykes, and Snyder and Broadway (2004), queering seems to mean adding queer (n.) identities to institutionally recognized categories of diversity, and adding queer (n.) content to already overstuffed textbooks. Including "'queer' in the hegemony" (p. 294) is not what Broadway (by 2011) had in mind for queering. Let's pause here for a reality check. Science education is nowhere close to the assimilationist vision of including queers (n.) among the normal. We should be so fortunate to have to radically queer classrooms replete with normalized gay and lesbian identities and science content about diverse sexes, sexualities, and genders. That said, we share Broadway's distaste for visions of queering as assimilationist projects of liberally inclusive normalization. This reduces queering to a politics of identity that fits comfortably enough within tolerant heteronormativity, the curricular companion to same-sex marriage and out lesbian soldiers (stunning achievements in their own right that are ripe for queering).

Against the evident impulse to queer (v.) just enough to normalize queers (n.), Broadway gestures to the queer curriculum as storied journeys of self, other, and the world that arc from the familiar to the strange. Queer pedagogies propel storied lives in relations of learning that put at risk illusions of a unitary, sovereign self. We imagine with Broadway a queer science education as entailing inquiry into the implications and complicities (Davis and Sumara 2000) of self, science, and nature. As we queerly interrogate the desiring subjects who know and do science, we necessarily interrogate the co-constitutive relations of those subjects with the 'natural' objects they conjure to fill textbooks with claims about what is normal, natural and human, and what is not. Lived inquiries into the complicities of

knowing and being do not require esoteric understandings of queer theories. Lee gained disturbing and productive insights into these complicities as a student teacher when he set up the biology he was teaching against his lived experiences as a young gay man in the process of coming out (Fifield and Swain 2002). But by delving deeply into queer theories and other critical interpretive frameworks we can create conditions for more intentional experiences of and skillful inquiries into being(s) in the science curriculum. This puts love of learning, and learning to love, in a new light if learning is putting the self at risk by mindfully excavating and engaging the contingent relations that lie behind the illusion of an essential, autonomous self, and love is opening in awareness to the complicities of being(s). The love of putting the self at risk to more fully participate in the complicities that the autobiographically coherent self denies, queers the preoccupation with self that so distracts conventional (and many queer) visions of (science) education.

Who's this work for?

Lundin, like Snyder and Broadway (2004) and Bazzul and Sykes (2011), wants to foster education that "attracts and relates to all students." Attempting that in part necessitates pondering the 'all' in the popular reformist mantra, 'science for all.' By un-resting both the 'science' (as illustrated above) and the 'all' in this slogan, we demonstrate how these seemingly broad-based and inclusive categories function as much to maintain the status quo as they do to upend or challenge it. Our aim is to elucidate the intentions, limitations, and (deadly) silences in what appears to be a laudable and ambitious goal. The 'science for all' ideology may seek to expand the demographic terrain of a technoscientific worldview, but it leaves unexamined how the meanings of science might be reformulated in and through the lives and cultures it now seeks to engage (or is it capture?). In this sense, 'science for all' entails a discourse of invisibility (Rodriguez 1997) in which the lives of those we wish to include in science education are homogenized and reduced to those who already dominate science education and the broader culture.

We need to be clear about who we're talking about when we do this work for 'all' students. From a queer(ing) standpoint, we do not take the diverse identities within the cultural admixture that is the 'all' as homogeneous, stable, coherent, or entirely knowable. Just as the identities of students are in play and at risk during encounters with science via science education (Luhmann 1998), the meanings and practices of science and science education can be (and often are) questioned and transformed through the diverse standpoints and identities of students and teachers. Viewed in this way, 'science for all' holds, paradoxically, the possibility to open up and nurture the ways in which science education is already quite queer, even when it outwardly might seem anti-queer. Thus, we refuse as undertheorized the use of *all* to signal what had once been an incomplete, partial, or exclusionary consideration of groups of people who, once they are named and included, make the 'all' more all-embracing and complete. Used in this way we see 'all' as code for those once neglected, ignored, and under erasure. "This 'add LGBT and stir' approach leaves untheorized the multiplicity of ways that sexuality is a crucial dimension of teacher practice, student learning, and the production of knowledge" (Letts 2002, p. 119). The issues of queering science education are more fundamental and foundational than the laudable, but limited, goal of including lesbian, gay, bisexual, transgender, transsexual, queer, questioning, and intersex students/identities/subjectivities/perspectives.

Queering can suggest that outsiders are in important respects already insiders, and that hetero norms are queerer than we may imagine. We have already suggested, following

Diana Fuss (1991), Luhmann (1998) and others, that the co-constitutive nature of hetero and non-hetero, of normal and Other generally, dissolves putative binaries into ambiguous and fluid relationships. For instance, the adolescent boys that are so often featured defending heteronormative boundaries by harassing their peers and teachers (Nayak and Kehily 1997) do so by venturing into the hazy borderlands of normal and abnormal. In displays like the one Lundin describes in which Tom says, "I am Richard and I like dicks," Tom mockingly plays the role of the sexual stranger, "neither us nor clearly them, not friend and not enemy, but a figure of ambivalence who troubles the border between us and them" (Phelan 2001, pp. 4–5). Lundin notes Tom's switching of subject positions, but he seems more concerned by how Tom repeats heteronormative stereotypes that reinforce Otherness, than he is intrigued by how Tom's enforcement of the hetero norm enacts its own transgression. Heteronormative boundary work necessarily occurs in interior frontiers where distinctions between normal and abnormal lose the clarity they seem to have when viewed from a distance. It is precisely in these ambiguous borderlands where one experiences firsthand the mutually constitutive co-arising of the normal and the stranger, the interbeing of self and others (Hanh 2009).

We share Lundin's concern with how seemingly playful boundary work like Tom's deals in stereotypes that reinforce harmful hierarchies. But our take on episodes like this one reflects an interpretive shift away from normalizing the Other, to queering hetero (and other) normalizations. Heteronormative boundary work that offers the pleasure of vicariously enacting its own violation can be queerly seen as the manifestation of desiring to know and knowing desire. In the spirit of Lundin's suggestion that behavior like Tom's may contain the seeds of educative performance, those concerned with equity and inclusion might relate in new ways to boundaries (which will be with us as long as we desire to conceptualize, systematize, compare, and contrast) as pop-up spaces for situated, transgressive inquiries into knowing and being. While progressive science educators normally think of inquiry as the path to more and better knowing, to resolving (at least some) ambiguity, a queer inquiry also insists that we take on the hard work of relaxing our attachments to what we think we know and desire about (our) selves and subjects.

Lundin suggests that equity and inclusion would be advanced through an "orientation towards uncommon subject positions" gained through the "process of getting used to and familiar with things that are not part of the norm." Alas, queer theories pose to this humane and enlightened call to emancipate the Other from stereotypes "the difficult suggestion that knowable subjects are merely another form of subjection to normalization" (Luhmann 1998, p. 146). By claiming to know identities as "sheer positivit[ies]" (Britzman 1995, p. 155) the ineffable evanescence of being(s) in shifting social relations and phenomenological improvisations is obscured by "reductionistic identity categories" (Carlson 1998, p. 112) that are the regulatory currencies of curricular exchange and pedagogical relations. Instead, "queer theory asks that the form of curriculum and the relations of pedagogy be appropriated as spaces to interpret the minutiae of differences among persons, not merely among categories of persons" (Sumara and Davis 1998, p. 198). Rather than making the strange familiar, a "story of learning [that] sees homophobia as a problem of ignorance" (Luhmann 1998, p. 143), queer theories seek to make the familiar strange. Pedagogical encounters with strangers who resist being known can incite unsettling wonder about one's self in relation to a world that confuses one's expectations while teasingly soliciting them (Fifield in press).

More engaging (of) science

To get beyond a "critique of what is there (and not there)" (2011, p. 289), Lemke pushes those interested in queering science and science education to take up multiple theoretical frames in addition to queer theory to contend with the "real complexity of socionatural systems" (p. 292). This call to not get boxed-in by queer theories is wholly in the spirit of queer theories to promote "thinking against the thoughts of one's conceptual foundations" (Britzman 1995, p. 155). Just as Lemke (2011) bemoans the masculine and politically conservative nature of science, Judith Halberstam reminds us that, "Disciplines qualify and disqualify, legitimate and delegitimate, reward and punish; most important they statically reproduce themselves and inhibit dissent" (2011, p. 10). So we would add that the queering of science and science education should feel free to interrogate, and in this sense participate in, all of science (here we are, back to the 'all'!), not just the usual suspects of genetics, hormones, anatomy, and behaviour in relation to human sexualities. Queer theories are deeply interested in sexualities and genders as far reaching manifestations of desire, but we should not suppose that sexualities are the only paths into queering inquiries. Broadening our frame to consider the dynamics of desire, knowing, self, and other can extend the reach of queering perspectives. We might, for instance, approach the sciences as entangled systems of identity politics that conjure and normalize certain entities and processes to construct the natural(ized) world. Individuals, research groups, and disciplines build and contest identities in relation to the entities they study (Gieryn 1999), and those entities take on (and resist) identities in relation to science. Through breathless inversions of causes and effects, scientific constructions are presented as universal truths discovered about a pre-existing natural order that science ("technoscience" is more apt here) claims the special ability and authority to reveal and manipulate.

From this queering stance, we don't intend to limit (the analysis of) science as identity politics to conventionally demarcated bodies of knowledge, ways of knowing, or communities of practitioners. We have something more fractal in mind, as we consider how the queering of science might zoom in and out to trace at different levels of resolution the mutually implicated and complicitous actants (e.g., 'natural' entities, scientific disciplines, ways of knowing, scientific experts, the public, 'pseudoscience,' etc.) at stake in the identity politics of science (Latour 2005). The identities in play include those entities defined by/as scientific conceptualizations: e.g., ecosystems, protons, sperm, entropy, wallabies, evolution, the carbon cycle, helium, lactose, recessive alleles, etc. As Sandra Harding (1993) notes, "scientists' [and we would add teachers' and students'] own interactions with such objects also culturally constitute them: to treat a piece of nature with respect, violence, degradation, curiosity, or indifference is to participate in culturally constructing such an object of knowledge. In these respects, nature-as-an-object-of-knowledge simulates social life, and the processes of science themselves are a significant contributor to this phenomenon" (p. 17).

This approach presents yet more binaries to variously appreciate, undermine, and think and act beyond. Science orders to possess (and possesses to order) nature in normalized and naturalized categories. In this scheme, nature exceeds science, but science sets the limits on how much of nature we can know and speak of with authority. Those who desire scientific knowledge must wait on its progress to know more of nature. Natural entities too must wait to be authorized into being by science, even as science humbly claims to have merely revealed, rather than authored, its truths. Science imagines that nature exceeds its grasp and holds secrets that science desires and must come to possess if science is to avoid descending into scholasticism (such as conventional school science). In this sexist and

heteronormative embrace, nature possesses science, holds its gaze, coyly hiding its truths to make science work for what it wants (Schiebinger 1993). One of us recently heard a Ph.D. physicist and science educator tell an audience of university faculty about how glaciers "contain scientific information" that is, regretfully, being lost due to rising global temperatures. It seems that nature (as manifest in glaciers) contains, prior to any human intervention, scientific information waiting to be claimed by scientists. Here "the object of consideration is envisioned as existing outside the conditions of its perceivability" (Honeychurch 1996, p. 345), even as the co-constitutive weight of the subject/object distinction collapses one into the other.

There is a certain satisfaction in upending scientific master narratives, but it's a cheap thrill. Following Lemke's call to find and create alternatives to what we queerly criticize, it is time for those who would queer science education to turn an appreciative and critical eye to science that is advancing views of relationality, complexity, and contingency to understand the complicities of being(s) (Davis and Sumara 2000). For instance, Anne Fausto-Sterling's (2000) work, which is rich with just the sorts of biological realities that biology textbooks routinely disregard, leaves the reader astounded at just how much work it takes, and how much diversity must be ignored and discounted, to construct scientific understandings that accord with cultural conceptions of female and male bodies, and feminine and masculine beings. Donna Haraway's (2008) notion of 'becoming with' further opens approaches to individual development and evolution that both mark and think beyond deeply rooted cultural and scientific assumptions concerning self and other, and the autonomy of species. Queer theories cheekily suggest that the more stridently we insist on unambiguous distinctions between self and other, this and that, the faster these distinctions blur in co-constitutive processes that refuse the separateness and autonomy we so desire. This leaves us forever toiling individually and culturally to create the natural boundaries that nature so inconveniently refuses to supply.

As with accommodating sufficiently straight-acting gays and lesbians into the heteronormative fold, sometimes it is simply easier to admit the Other into the norm (or the self), and to proceed as if this new state of affairs is and always has been normal. Each of us is a manifestation of a host of Others that go unrecognized. One of the queerer ideas that now passes for normal in biology textbooks is that several types of organelles in eukaryotic cells (e.g., mitochondria, chloroplasts, flagella) are descendents of what were once free-living organisms. What's more, genomes reveal a heritage of promiscuous mergers and acquisitions that far exceed the phylogenetically tidy union of egg and sperm. Lynn Margulis and Dorion Sagan (2002) construe these queer evolutionary relations as the "co-opting of strangers" (p. 205), a perspective that invites intriguing comparisons with Phelan's (2001) sociocultural work on sexual strangers. Stranger still is how nonchalantly textbooks gloss the idea that our genomes and cells contain the traces of creatures we would clearly see as Other, not as self. Of course, we are all the descendants of creatures that were neither our selves nor what we would recognize as our kind. These and other facts of life refuse the regime of binaries that has so concerned queer theorists. But facts do not speak for themselves. Against the reductionist and mechanistic models that dominate the curriculum, queer perspectives invite learners to, for instance, reimagine self and Other through the paradox of the subcellular strangers we take as parts of our selves. Seeing and enacting relationality in/as science dissolves the distinction of relational issues versus science content that constrains Lundin's analyses, pointing the way to different understandings of the complicities of being(s) in science, learning, and society. In this we are not so much "advocating for a 'new' or 'better' school science," as we are suggesting that in a broad view of queering science education, the "discursive production of science itself becomes the curriculum in critical science literacy" (Letts 2001a, p. 270).

Empirical desires

We need more empirical work that, as Lemke (2011) suggests, uses multiple theoretical frames to better engage the complicities of science, desire, and being(s). Building on earlier analyses, Lundin's move into classrooms is a promising approach to tracing across a broader landscape the recursive curriculum paths through culture, national educational policy documents, the formal curriculum, how teachers enact the curriculum, how students experience it, and how researchers re-tell these tales. Putting these multiple, overlapping enactments of sense-making in play, including how each shapes and is shaped by the other, counters some of the weaknesses of more isolated analyses that take texts and classroom vignettes at face value, as if passages and images from textbooks or snippets of classroom dialogue contain stable, unambiguous meanings.

Lundin's paper contributes valuable data and insights to the body of work in queering science education, perhaps offering, as we suggest, even richer possibilities than he claims. We wish that Lundin had looked more closely at the sense-making going on in the classrooms he visited. As a classroom inhabitant, and as an analyst, he seemed to maintain a distance from the action that limited his resources and affordances as a sense-maker. This distance was established and maintained, in part, by inserting Judith Butler's (1990) ideas between himself and his subjects. Drawing on Butler was a wise move, but we wonder about domesticating her ideas in a conceptual framework that sometimes seemed to set limits on attention and imagination. This imposed a deductive trajectory to the study, as Lundin fit data into the preconceived niches of the framework. The interpretive framework accommodated familiar elements of heteronormativity, rather than unsettling preconceived notions of heteronormativity to explore just how queer(ing) heteronormativity sometimes is.

We also wish Lundin had included conversations with teachers and students as a way for him (and his readers) to become more intimate with the meaning-making he investigated. What were the teachers' intentions for the lessons, and how did they think they went? How did teachers think about the connections between their lessons and curriculum policy documents? How did they make sense of students' language and interactions? And how did students feel about these lessons? What did they think they learned? And what, for that matter, did they mean by dickhole and wet cave? We want to engage these conversations not because we think they hold more authentic or truthful meanings, that by going to teachers and students we can access what really happened. Instead, we want to hear from students and teachers because we want Lundin and his readers to be more implicated and complicit in meaning-making, so they/we can generate new, divergent meanings. We want queering inquiries like Lundin's to entangle researchers, teachers, students, and readers in distributed sense-making that disrupts the understandings that fix our selves into identities. In this complicitous knowing we are more likely to "engage the limit of thought—where thought stops, what it cannot bear to know, what it must shut out to think as it does…" (Britzman 1995, p. 156). In this sort of queering inquiry we can work with ignorance and resistance, not as the absence of knowledge, but as [co]"constitutive of knowledge and its subjects" (p. 154).

What's a teacher to do?

Broadway (2011), echoing an oft-heard refrain, laments about "how (queer) theory helps (science) classroom teachers do what they do, or is expected of them by the hegemonic

capitalist school often called education (Brosio 1994)" (p. 300). We understand this concern at one level. The task of upending and refusing normalcy in a discipline that is intelligible because of its insistence on normalcy, on recognisability, on a lucid and understandable narrative and on repetition, seems unintelligible. But if all the while you find yourself wondering, as we sometimes do, What can a teacher take from all of this to use in class on a Monday morning?, we think the first step is to excavate your assumptions about teachers and their sense-making abilities. There isn't a threshold one must cross to 'really' be using this information in powerful and evocative ways. There are as many ways to take up these ideas as there are teachers and classrooms.

Why not ask a teacher, What did you take from all of this that's of use to you? What might teachers make of some of the classroom interactions documented in Lundin's study? Maybe they'd comment on the proliferation of dichotomies that seem to arise in the work—traditional science [facts] versus relational issues; traditional sex versus non-dichotomized views; known [one's own sex] versus unknown [the "opposite" sex]; attractive features on males versus attractive features on females; penis versus vagina. They might marvel at the apparent sexism in the asymmetry of naming breasts as a female site of attractiveness, but not including the male chest on the comparable list. Or they may note the heterosexism evident in the presumption that the students will be attracted to the "opposite" sex. They might recognize the problematic nature of "the automatic slippage that superimposes dichotomous notions of gender—femininity and masculinity—[or sexuality] onto 'biological' sex in such a way that makes gender [and sexuality] also seem dichotomous, discrete, polarized and 'natural'" (Letts 1999, p. 103).

In the activity Lundin describes where students listed nicknames for penis and vagina, teachers might puzzle at the scope and scale of normativity and how it's manifested in curriculum and pedagogy. To acknowledge heteronormativity in binaries such as male versus female, or homo versus hetero, is too partial a response. Heteronormativity abounds not just in students' responses to the names of sex organs, but in how the whole classroom activity was structured and bounded to ensure that (only) normative responses were elicited. The activity was reduced to penis versus vagina, a normative, dichotomous construction of sex organs, as opposed to considering breasts/chest, nipples, anus, skin, mouth, tongue, nose, hands, and ears as sex organs, for instance. Teachers could be astonished at the absurdity of a teacher imploring, "You are supposed to choose, even though you know nothing about these blokes, which one you would like to be in a relationship with" (Lundin 2013). They might also appreciate their colleagues' efforts to spark difficult conversations that connect the issues of sexual education to students' lives. For "what is at issue here is not [only] about a static body of content (science), but rather how science content gets enacted by teachers through pedagogy" (Letts 2001b, p. 194).

As we have suggested, queering must not be only about sexuality or issues obviously connected to sexuality. Limiting these issues to sex/gender/reproduction ghettoizes this material and packages it too neatly, partially, and inaccurately. Once we move to a framework that accommodates desire, we open more of science—its cultures, actors, narratives, metaphors, analogies, and facts—to rigorous queer critiques. We see then that the 'facts' included in texts and lessons about sex/gender or hormones aren't, in fact, facts. Suddenly curricula and pedagogies present themselves for closer examination. Expository texts like textbooks (or lessons, lectures, podcasts, and activities) might quite unintentionally present possibilities for critical reading practices that identify the missing, the silent, the absent and the normative, which could help students and teachers work on Luhmann's (1998) questions: "How do we insert ourselves in the text? What positions do we refuse? Which ones are desirable?" (p. 149).

All of this might require more than just additional/other/more inclusive content. It might hail or insist upon new ways of looking at the content that is already there—to render the intelligible less so, to make the familiar strange. For example, couldn't any text serve as good material for queering by students and teachers? Might just the acts of identifying the blind and silent spots, excavating the hidden, and naming the missing or excluded be instructive and generative? Perhaps we're not accustomed to thinking of science textbooks—or textbooks more generally—in this manner, but what if we did?

What could a teacher take from all of this? Anything they want to, anything of use, anything that affords them a broadened view of their students and the important work they do. 'To queer' is to denaturalize coherent selves, to resist the narrow logic of binaries, and to dislodge the sense of safety that comes with 'really knowing.' Queer insists "that non-straight sexualities are simultaneously marginal and central, and that heterosexuality exists in an epistemic symbiosis with homosexuality" (Luhmann 1998, p. 144). A different, broadened view of science might allow us to "provide more resources to our students for the construction of varied identities that thwart the hegemonic presentation of science as a master narrative" (Letts and Fifield 2000, p. 12). In relation to science curricula and pedagogies, "Queer theory does not ask that pedagogy become sexualized, but that it excavate and interpret the way it already is sexualized…heterosexualized" (Sumara and Davis 1999, p. 192). Thus, science pedagogy and knowledge "might be posed as a question (as opposed to the answer) of knowledge: what does being taught, what does knowledge do to students?" (Luhmann 1998, p. 148). And just imagine what sense teachers (and students) can make of all of that!

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