

Re-Visioning Science Education from a Science Studies and Futures Perspective

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Abstract

It is heartening to note that while science education remains predominately conceptualised from normative positions, there is a small but important literature adopting more critical perspectives. Drawn from the oppositional discourses including science studies and ecofeminism, such critiques aim to reformulate science education with far-reaching implications for science curriculum. Given the centrality of science in the Western worldview and the future of the planet, a futures perspective is a critical omission from these critiques. Futures thinking can provide a novel framework for organising the critiques of science, and facilitate the development of principles to re-vision a more open science education.

Introduction

The special space afforded by the advent of the new millennium provides the science education community with a unique opportunity to engage in critical reflection on the roles science and science education play within the 'big picture' state of our global community and its future. In a world facing ecological degradation, and driven by global capital imperatives derived from technoscientific agendas, the importance of a relevant, critical and just science education cannot be overstated. Like other educational endeavours, science education is a vast and diverse field. It has developed its own areas of interest distinct from the concerns of academic scientists, general researchers or teachers, only since the curriculum reforms of the early 1960s (Fensham, 1997). Its interests range from classroom-based teaching and learning, curriculum, teacher and student-related factors, historical perspectives and so on, to policy development, and to the more theoretical epistemological, philosophical and sociocultural concerns in the nature of science itself.

While these areas are formulated predominately in normative terms, there is a small but important scholarship of critical perspectives reflective of the cultural and linguistic turn in social science theory more generally (see for example the work of Appelbaum & Clarke, 2001; Calabrese Barton & Osborne, 1998; Kyle, 2001; Weaver, Morris & Appelbaum, 2001). Owing much to the field of science studies and other oppositional discourses such as ecofeminism, these critical perspectives include the social-interactional, the historical, the linguistic, the political, the sociological, the ecological and the economic (Lemke, 2001 that for Wong (2001), together with post-modern and feminist thinking, are part of enlightened contemporary science education discourse. In this paper we contribute to this discourse, and briefly review the critiques of Western modern science as a means of elaborating some emergent guiding principles we believe are important for developing relevant science education. Within these principles we include a futures perspective that we judge to be absent from such scholarship. More specifically, we describe the development of a teaching

unit for pre-service primary teachers that attempts to problematise science from social, historical and futures points of view.

Science as Consciousness and Practice

Re-visioning a science education capable of contributing to a more just future requires an understanding of the deep structures of science and in particular, Western modern science and technology. Woolgar (1988) argues science to be a complex and ambiguous field described by a range of epistemological, philosophical, sociological, cultural and historical perspectives. It is both a form of cultural imagination that underpins and pervades the modern, global matrix with distinctive types of rationality, values, and claims to universality, what Fuller (1997) calls an 'Enlightenment consciousness', and the more specific truth-seeking practices pursued by elite professionals to various ends (Galison & Stump, 1996; Proctor, 1991). There is also recent and growing interest in local knowledge systems, ethnosciences and science as local cultural practice (Harding, 1998).

Characterising science as 'consciousness' means regarding science as "the dominant world explanation of modernity" (Heller, 1999:76), in other words, acknowledging science as modernity's referent for legitimating truth statements. It is this scientific 'consciousness' that firstly, colonialism and now, globalisation imposes on the world, through modernisation's normative ideas of rationalisation, institutionalisation, autonomy, progress, and the rational calculation of the future. For Heller (1999) the power of science as 'consciousness' is self-evident, as even within postmodern times, it has resisted the loss of its authority. On the other hand, modern Western science as elite 'practice' interrogates the world generating unproblematic sets of repeatable truths. Its numerous specialisations systematically develop a view of reality as they incrementally fill out the details of their various domains. This science believes itself to be universally applicable and epistemologically internally-directed, owing much, Hess (1995) argues, to its selectively constructed origin story that has been retold so many times it no longer has any rough spots. The origin story is a narrative of the triumph of

reason as the torch, "unique in its quest for the ultimate, singular and unified truth" (Fuller, 1997:80), is passed from one Great White European Male to another, establishing the assumptions about science, technology, nature and modernity that inform its current practices. It has generated a false consciousness that has effectively 'blackboxed' scientific practice beyond the scrutiny other disciplinary areas have had to endure (Kendall & Wickham, 1998). Science has consequently resisted the sceptical inquiry it has routinely applied to the other, and in doing so, has presented a united front able to safeguard its privileged and unique status for setting the boundaries of knowledge (Gieryn, 1999).

Critiques of Science

While science has provided powerful and reliable knowledge enabling much human flourishing, it has also become highly problematic (Galison & Stump, 1996). De Landa (1996) suggests one of the most significant epistemological events in recent years has been the postmodern turn in conceptualising science. Science has become a contested site, its identity destabilised as its claims to value-free, objective and universal truth have been progressively undermined by counterclaims of the social construction of scientific knowledge (Gieryn, 1998). The resultant so-called 'Science Wars' (Ross, 1996) has proponents such as Wolpert (1997), Gross and Levitt (1994) and Sokal and Bricmont (1998) aligned against those whose more critical perspectives have emerged from the fields of postcolonialism, poststructuralism, cultural studies, sociology, anthropology, and feminism. Known collectively as the cultural studies of science (Weaver, 2001; Weinstein, 1998), the sociology of scientific knowledge (Rose, 1997; Turnbull, 2000), and elsewhere as science studies (Jasanoff, Markle, Peterson & Pinch, 1995; Sardar, 1996) or science and technology studies (Harding, 1998; McGinn & Roth, 1999), together these fields more thoroughly examine the nature, history, production and sociocultural location of European and ethnosciences, and other local knowledges. We use the term 'science studies' here to be representative of these positions.

Science studies is a heterogeneous assemblage of subfields not reducible to a single position yet efficacious in their interrogation of a range of practices and discourses. Science studies argues that we can only know nature through culturally constituted conceptual frameworks, enabled and limited by local cultural features such as discursive practices, institutional structures, interests, values, cultural norms, and so on (Turnbull, 2000). Within this view, Western science is itself a local knowledge system, or indeed ethnoscience (Hess, 1995), which cannot be known in isolation from the cultural intentions, purposes, and values that has shaped its knowledge claims. Harding (1998) organises science studies into the two schools of post-Kuhnian and postcolonial. Post-Kuhnian science studies focuses on the construction of Western scientific knowledge within the cultures and practices of scientific institutions, permeated as they are by social and personal beliefs. Harding (1998) describes microsociological laboratory studies illuminating the interrelationships between scientific method and knowledge to understand how scientific statements emerge from practice. They show scientists become involved in long, messy processes that include individual values, tacit knowledge, social negotiation and reputation to distil meaningful data from the background wash, persuading themselves and others that their interpretations are valid. As emergent statements pass through a series of modifications, references to social, historical and personal contexts are progressively shed, and the scientific claim rises in status (also Collins & Pinch, 1993; Knorr-Cetina, 1995). Science behind the scenes, it would seem, is characterised by the same messy and conflicting social and cultural constructions as any other knowledge field (also Turnbull, 2000).

By contrast, postcolonial science studies moves beyond Kuhn's preoccupation with Western science, to postcolonial and localised perspectives emerging from the globalising worldview. Also known as oppositional science studies (Haraway, 1996), their purpose, notes Harding (1998), is to expose the subjugation and assimilation of the other's different scientific traditions. Postcolonial science studies argues the

view contentious within the 'Science Wars', that Western science and the other's knowledge traditions should be treated on an epistemological par as each developed in response to their culture's need to understand, predict and influence its environment. Goonatilake (1998) for instance, discusses recent work indicating that many indigenous groups use processes congruent to Western science in their systematic exploration of nature. Postcolonial science studies also draws from anti-Eurocentric histories such as 'science and imperialism studies' that have begun to reveal links between European colonialism and the new kinds of oceanography, cartography and botany that it required (Osborne, 1999; Paty, 1999). These voyages turned the world into a laboratory for European scientists to test their hypotheses and to forage in the traditions of the other, appropriating their knowledge without acknowledging its origins. There are numerous instances where the Islamic, Indian, or Chinese civilisational sciences or other indigenous ethnosciences have been incorporated into Western science. Intentionally or not, Europeans destroyed the other's knowledge traditions that would have offered the greatest competition to Western science, or could have provided "potential trajectories of knowledge—trajectories which, if they were developed, would have led to different explorations of physical reality" (Goonatilake, 1998:70; also Hess, 1995). Western science has defined itself as "the only way of knowing, the sole path to universal knowledge, the exclusive arbiter of what is true and what is false" (Sardar, 1996:226, his italics). Within Bauman's (1995) view of modernity, Western science is privileged truth whose might resides in its power to define and make the definition stick.

Both Post-Kuhnian and postcolonial science studies also incorporate contemporary feminist perspectives. The writings of Fox Keller (1985), Haraway (1989) and Merchant (1980) suggest that science predominately investigates questions important to such dominant social institutions as transnational corporations and the military, from which women have been systematically excluded. They argue that preoccupations of these social structures do not arise from

women's lives nor serve women's interests.

Consistent with these critiques of science are those from the ecological domain, particular from the ecofeminists. Shiva (1994:15) argues that reductionist science is an inherently violent epistemology, a "masculine and patriarchal project that necessarily entailed the subjugation of both nature and women". The Cartesian mind-body split saw the body become associated with the seeming irrationality of nature, and of women, while Bacon's scientific method ensured nature (and women) was a resource to be manipulated. The participatory consciousness as the sense of being part of nature, and descriptive of the relationship between nature and pre-rational communities, was desacralised and destroyed (also Broomfield, 1997). Moreover, many scientists themselves have become concerned with the scale of destruction of the planet's ecological systems and the unsustainable nature of human activity. Key members of the science community including the Union of Concerned Scientists (UCS) produced the 1992 declaration starkly titled "World Scientists' Warning to Humanity". Lowe (2001) believes that sustainability is the issue of the 21st century, and has called for 'sustainability science' to be a recognised discipline.

These strands of science studies erode the mythological status of universal science within the rationalising framework of modernity, and refract it through the prism of culture. Science becomes bound and mediated through cultural codes, and social and economic power interests that need to be teased out and exposed. Indeed commentators, according to Aronowitz et al. (1996:8), "have often claimed that science is the dominant institutional and ideological player in the global cultural scene, the one that most dramatically affects or ... permeates our corporeal, subjective and social being". However, powerful as these critiques of science are, they largely neglect any significant futures thinking. While future studies acknowledges the theoretical contribution of science studies as a way of exposing the scientific and technological 'enframing' of the West (see for example Slaughter, 1996), there are few if any works from science studies that include an explicit futures perspective. We find

this somewhat surprising given the purvey of science studies, and have argued elsewhere that science studies and futures studies exhibit considerable overlap (Carter & Smith, 1999). They are both contentious transdisciplinary enterprises drawing from similar intellectual and perspectival epistemologies and methodologies, and much science studies scholarship can be judged to hold implicit futures perspectives. As we believe science studies continued neglect of the futures discourses is in danger of limiting its intellectual project, we include futures perspectives in any of our thinking derived from science studies.

The Role of Science Education

Turning now to consider the role of science education, it is perhaps to be expected that normative science education recapitulates the dominant view of science as unproblematic sets of universally applicable, epistemologically valid, repeatable truths stepped within its origin myth. Current science curriculum derives from Britain and America's massive 1960s science education reform efforts delayed by World War 2 and the Great Depression (Fensham, 1997). The reforms were contextualised within the political and economic agendas of the Cold War, and an unbridled confidence in the social benefits and utility of modern Western science. While the primary level privileged science processes and concrete 'hands-on' experience over content, the secondary level revised well-established, theoretical topics to better fit approaches used at university for training vocational scientists and engineers. The science curriculum became highly abstract and organised around fragmented bodies of canonical knowledge, a sanitised understanding of scientific method, and a conceptualisation of science as objective truth-seeking within a unified view of reality.

Now, nearly half a century later, we find ourselves in a new global economic and political space. Where perhaps there was a possibility of something different, the need for a technological, flexible, productive but uncritical workforce to serve the interests of the emerging knowl-

edge-economies has determined the shape of contemporary science education. The neoliberal, neoconservative and regressive forces of globalisation have unfortunately envisaged school science yet again, as a steady induction into science formulated as a body of objectified knowledge and methodology (Hurd, 2002). These forces recapitulate the 1960s curriculum reforms into current standards-based science curricula that Hurd (2002:5) suggests is "(s)imply updating the traditional principles and generalizations of science disciplines". The science curriculum derived from a previous generation has been found to well-serve new masters!

In much the same way as science studies has critiqued the construction of scientific knowledge, they have also been used to critique this abstract approach to science curricula, and have hence been highly influential in the rise of science education's oppositional discourses. Science studies have lent themselves to being used in a variety of ways with some scholarship (see for example Cunningham & Helms, 1998; Costa, Hughes & Pinch, 1998; Kelly, Chen & Crawford, 1998; Kelly & Chen, 1999; Roth & McGinn, 1998) drawing on its research methodologies to explore school science as embodied sociocultural practices. Other studies situate science education in society and culture (Aikenhead & Jegede, 1999; Lee & Fradd, 1998), while still others have coupled the intersections of race, gender and class with socio-transformational education (Calabrese Barton & Osborne, 1998; Rodriguez, 1997). There is also scholarship on ways that practitioners can innovate congruent with science studies research (Hodson, 1999; McGinn & Roth, 1999; Weinstein, 1998), as there is around the implications of debates about the (McComas, Clough & Almazroa, 1998). Drawn largely, although not solely, from post-Kuhnian science studies, these accounts are among the myriad seeking to challenge and wri(gh)t/e science education (Roth & McRobbie, 1999). Together they argue for a science education that goes beyond imparting scientific knowledge and skills and advocates critical participation in a world dominated by technoscience.

Futures Perspectives and Science Education

It is hardly surprising that research studies suggest that students perceive the current but traditional abstract approach to science education as largely irrelevant to the realities of their complex postmodern and global world. Despite years of formal science education, their scientific misconceptions are common, and their lack of motivation and feelings of alienation show in the decreasing numbers opting to take science beyond the compulsory years (Dekkers & de Laeter, 2000; Eisenhart, Finkel & Marion, 1996; Millar & Osborne, 1998; see also Ogawa, 2001). Moreover, as futures research indicates that students' views of the future are dominated by both utopian and dystopian technoscientific images, the need for relevant and critical science education within a futures perspective seems more pressing than ever (see Carter & Smith, 1997; Mudzeilwana & Smith, 2001). A futures-derived science education provides the means to examine and problematise students' views, and their accompanying concerns about social and environmental breakdown. Futures concepts like foresight enable us to view the consequences of the products of Western science such as global warming and biotechnology, as having significant and unpredictable effects into the future. Problematising taken-for-granted scientific scenarios of the future allow discourses about the origin and inevitability of scientific products to be considered as well as different futures to be envisioned.

Towards a Re-vised Science Education

It seems to us that an approach to the science education which is based upon insights from science studies and critical ecology firmly embedded in futures perspectives is essential for a more relevant, critical and just science education for young people. Drawing together the strands of science studies, ecological discourses and futures, we suggest the following guiding

principles should inform science education. We note these principles are still a work-in-progress, and require greater elaboration and critique themselves. Nonetheless, we offer them here to commence this vital discussion within science education and futures. Science education should be:

• **Be framed in a futures perspective**

A futures perspective framed within futures studies is fundamental for considering ways forward. Futures studies offers a range of powerful concepts and tools for developing foresight and being proactive about creating a future worth having. Incorporating and problematising students' views of the future opens up both discussion of the origins of these views and consideration of other options for the future.

• **Be socially critical**

An understanding of the sociocultural construction of science derived from science studies enables a science education that actively deconstructs the master narratives of science, and reveals the privileged positions and interests associated with its production.

• **Include the history and philosophy of science**

An understanding of the historical and philosophical context of modern Western science is vital to exposing the sedimenting histories of the reductionist scientific worldview, and its exclusionary boundary construction and regulation role in the world of today. We believe a critical perspective is not possible without such an approach.

• **Focus on what it takes to create a sustainable future**

We believe that nothing less than a planetary framework is required for students to begin to understand the interconnectedness of life on earth. Earth systems can be used as a source of curriculum, and their resacralisation holds the key to their protection. Sustainability science focuses on relationships and systems as ways of understanding our world, as well as pertinent scientific processes, products and decision-making.

• **Include postcolonial perspectives**

We need to be attentive to the imperatives and perspectives of non-Western science within a postcolonial sensibility. Postcolonial thinking offers the promise of new ways of thinking at the intersection of modernity and coloniality that gestures towards future possibilities.

• **Invoke a sense of wonder and transcendence**

A sense of awe and wonder is part of all human experience. We believe it should be an integral part of any science curriculum, in contrast to the dry and abstracted bodies of knowledge currently in place. Awe is apparent when students can see their place in the vastness of space and time, and commences the process of rekindling our reverence for nature and our desire for a sustainable future.

Developing a Preservice Unit

We have attempted to use these principles to develop science curriculum in our own spheres of practice. The resultant first year undergraduate preservice primary teaching unit in science and technology is aimed students who by and large, do not have a strong academic science background, and are consequently more receptive to such an approach. The unit consists of 36 hours, currently consisting of an hour lecture and 2 hour tutorial. The significant content of the unit is delivered during the lectures, while the tutorials afford students the opportunities to present their research and discuss issues from the lectures.

We would like our students to understand that:

- Humans have always tried to understand and shape their world: science and technology are as old as humanity;
- All cultures create their own stories or cosmologies. Cosmologies provide a sense of awe and wonder about the universe we live in and our place within it;
- As science is a product of culture, there are many sciences as there are cultures. Scientific knowledge has hence arisen from local contexts and in response to local needs;
- Western science is a local and now civilisation-al knowledge tradition, shaped by human

forces and interests and far from the disinterested and objective body of knowledge it represents itself to be;

- Western science is a powerful and reliable knowledge tradition. It is responsible for both utopian and dystopian agendas. It has provided for much human flourishing while being mutually coproductive of the interests of capitalism and imperialism;
- Science has a powerful influence on futures thinking, and as such must be problematised;
- Technoscience and global consumer culture co-produce each other;

Outline of content

1. The universe story: Deep Time meditation (adapted from Swimme & Berry, 1992)
2. Cosmologies
3. Views of the future: what do they include? Where do the images come from?
4. Time lines: the human story and the rise of Western science
5. Energy and matter: the two organising concepts on Western science
6. Energy: historical and future use
7. Energy and consumption
8. Matter: history of use, understanding of structure, biotechnology and nanotechnology
9. Technology in a social context: the social shaping of technology
10. Technologies for the 21st century: critical examination of global culture
11. Revisiting views of the future: what do they include? Where do the images come from? What other futures are possible? What is the role of science and technology in framing the future?

Evaluation of this unit is still in progress. However, anecdotal evidence suggests that students appreciate science being approached in this way, finding it relevant to their lives and offering a broad view of science and technology from both an historical and a futures perspective. In the near future, we intend to prepare additional papers that not only describe the unit content in more detail, but also discuss the further development of the guiding principles, as well as report on student responses.

Conclusion

Science education faces particular challenges in the 21st century. While mainstream science education continues its normative, and what we consider to be outmoded, trajectory formulated around decontextualised abstract and theoretical concepts and methodologies, it is heartening to note there are some sections of the science education community interested in pursuing new directions. We add our voices to this oppositional discourse in the hope that the emerging guiding principles we have elaborated in this paper, and the subsequent innovative science curriculum we have developed, can contribute towards science education worth doing.

We note the contentious problematic surrounding the uses of the terms science, modern science, Western modern science, Eurocentric science and so forth. In this paper, we agree with Harding's (1998) more inclusive view of science, and follow Gough's (in press) usage to refer to modern Western science as that endeavour produced in Europe during a particular historical period, whose cultural characteristics have endured to dominate, as a consequence of Western imperialism, global understandings of science and the regulation of its boundaries.

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