

Transformative Science Education

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Education for Sustainability

How can we prepare science teachers with professional knowledge and skills for ensuring that teaching and curricula meet the global challenges of the 21st Century, amongst which learning to live sustainably on Planet Earth is one of our most pressing concerns? Education for environmental, cultural and economic sustainability has been a key focus of the United Nations for the past decade, underpinned by the Brundtland Report's advocacy of an 'intergenerational conscience' which recognises that meeting the needs of the present should not compromise the ability of future generations to meet their own needs (UNWCED 1987). The recent 'Rio+20' United Nations conference on sustainable development ratified this view.

But implementing education for sustainability is no easy task especially in science education. It involves much more than the traditional delivery and acquisition of objective scientific knowledge and skills. The Australian Government (DEWHA 2010) adopted a definition of education for sustainability to guide curriculum designers nationwide that emphasises development of higher-level abilities essential to becoming an effective citizen and change agent.

- Ability to explore and evaluate contested and emerging issues
- Ability to deal with complexity and uncertainty
- Ability to take action as an individual and as part of community
- Ability to gather evidence and create solutions

Science education for sustainability brings together science education, values education and citizenship education (including peace education) to focus critically on the interaction between the 'Big Three': (i) *environmental issues*, such as human-induced climate change and loss of biodiversity associated with exploitation of natural resources; (ii) *sociocultural issues*, such as loss of indigenous knowledge systems that were developed through prolonged adaptation to living sustainably within the natural world; and (iii) *economic issues*, such as the implications for the natural and social world of economic models premised on producing prosperity via unlimited growth.

For students to learn meaningfully and collaboratively about these 21st Century sustainability issues it is necessary that they develop higher-level cognitive and social abilities, including critical reflective thinking, cooperative decision-making, empathic and compassionate understanding of self and other, ethical awareness and values clarification, and commitment to personal and social action. The capacity of science teachers to prepare

students with these higher-level abilities depends on teachers themselves having developed the same abilities.

Thus the professional development of 21st Century science teachers calls for a more global perspective that takes science teaching well beyond the traditional (narrow) curriculum focus on *what* and *how* (or 'pedagogical content knowledge') to embrace a humanistic perspective on the ethical responsibilities of science education (the curriculum *why*) and the unfolding personhood of the student as a future citizen in a democratic society (the curriculum *who*). For such a perspective we turn to transformative learning theory.

Transformative Learning

Transformative learning theory has its roots in the work of Jack Mezirow in the field of adult and continuing education which came to prominence in the 1990s. Mezirow (1991) drew on philosophers such as John Dewey and Jurgen Habermas to reveal how our 'meaning perspectives' are subject to epistemic, sociocultural and psychological distortions that restrict the way we make sense of our experience of the world. Thus we have limited ability to participate fully as creative, communicative and self-determining agents in the processes of democracy.

For Mezirow, the key to transformative learning is to engage discursively with others in reflecting critically on the presuppositions underpinning our values and beliefs. Critical reflection emancipates us from our ideological prisons, thereby enhancing our conscious awareness of ourselves, others and the worlds that we co-construct. For Mezirow, the role of transformative learning in adult education is to prepare citizens as critical self-reflective thinkers capable of contesting taken for granted social norms and making ethical judgements that lie at the heart of the process of democracy.

Over the past 20 years Mezirow's ideas have been applied by many transformative educators to a range of adult education and training contexts such as higher education, the workplace and the community. His theory of transformative learning has been enriched and become more nuanced by embracing nonrational modes of thinking in which emotions, intuition, mindfulness and inspiration have an important part to play. Transformative learning theory has been coupled with theories of society, consciousness, wisdom, globalization, feminism, culture, and so on, to generate compelling aesthetic, spiritual, psychological and ethical perspectives on the role of adult education in helping to create a more equitable, peaceful, diverse and sustainable world (Taylor and Cranton 2012).

One of the uniquely powerful aspects of transformative learning is the focus on expanding conscious awareness of our situatedness in the world or, to put it more simply, in our understanding of who we are and who we might yet become, both as individuals and social beings (Morrell and O'Connor 2002). Such a transformation entails developing a heightened consciousness of the relationship between our outer (material) and inner (non-material) worlds. Transformative learning involves using cognitive, emotional, social and (for some)

spiritual 'tools' to reconceptualise and reshape this relationship. Based on this perspective, transformative learning comprises five distinct but interconnected ways of knowing.

- *Cultural-Self Knowing* (self realisation) involves coming to understand our culturally situated selves, in particular how the (mostly invisible) premises underpinning our worldview – our shared values, beliefs, ideals, emotionality, spirituality – give rise to our cultural identities and govern our habituated ways of being in, making sense of, and relating to our social and natural worlds.
- *Relational Knowing* (opening to difference) involves learning to connect empathically and compassionately with our true (nonegoic) selves, our local community, the culturally different other, and the natural world.
- *Critical Knowing* (political astuteness) involves coming to understand how and why (political, institutional, economic) power has structured historically our social realities by creating seemingly natural categories of class, race, gender, vocation, intelligence, etc., and how this mostly invisible power governs (especially distorts) our lifeworlds, our relationships with others, and our relationship with the natural world.
- *Visionary and Ethical Knowing* (over the horizon thinking) involves us in creative, inspirational and discursive processes of idealising, imagining, poeticising, romanticising, meditating on and negotiating a collective vision of what a better world *could be* like and, importantly, what a better world *should be* like.
- *Knowing in Action* (making a difference) involves consciously developing our capacity to help make the world a better place, committing to making a difference, and taking action locally while thinking globally.

Research as Transformative Learning

The question arises as to how to engage science teachers in transformative learning in order to prepare them with the higher-level abilities to pass on to their students so that they learn to participate individually and collectively in complex evidence- and ethics-based decision-making processes about living sustainably in an increasingly crisis-ridden and uncertain world buffeted by competing (economic, political, sociocultural) interests.

In recent years transformative learning theory has been instrumental in re-theorising postgraduate educational research, resulting in a model of 'multi-paradigmatic research design' (Taylor et al. 2012). Building on developments in social science research over the past 30 years, this Kuhnian revolution has broken the stranglehold of (but not rejected) the traditional positivist paradigm wherein objective ways of knowing rule. For creative researchers the door has been opened to a range of innovative, exciting and empowering epistemologies that enable research as transformative learning to flourish. These epistemologies derive from research paradigms some of which are relatively new to science education.

The *interpretive* research paradigm offers a social constructivist perspective on the researcher's endeavour to develop deep, contextual and emergent understanding of the culturally different other, together with a reflexive process of deepening his/her own culturally situated self-understanding. Ethnographic, autobiographical and narrative methods are used to explore the lived experience of the researcher and his/her coparticipants. A powerful interpretive methodology used by researchers to excavate their life histories and recover lost cultural capital due to centuries of colonisation by the Western modern worldview is *auto-ethnography*.

The *critical* research paradigm arms the researcher with an epistemology of ideology critique aimed at identifying sociocultural myths (made powerful by their invisibility) that structure social reality and contribute to perpetuating social injustice, cultural exclusion, inequity, racism, sexism, ageism, scientism, etc. A methodology of *critical auto-ethnography* enables the researcher to work towards decolonising his/her own lifeworld, and ultimately the lifeworlds of students and/or colleagues, in a creative endeavour to enhance self-realisation, identity and free will as a prospective agent of social and structural reform.

The *postmodern* research paradigm brings a Janus-like (or two-faced) perspective to science education research. One face looks towards a philosophical deconstruction of the premises of all claims to secure or foundational knowledge (such as 'scientism'), whilst the other face wears the smile of constructive playfulness. Postmodern researchers draw on the Arts for new methods of reasoning and modes of representation (see, for example, Knowles and Cole 2008). Literary and artistic genres, such as fictive writing, poetry, ethnodramas and imagery, embody innovative logics for researchers to make sense of and portray their nonrational experiences of the ineffability of their social and natural worlds.

Multi-paradigmatic research designs provide powerful ways of engaging researchers in transformative learning about the underlying premises of science education (Taylor, 2013). 'Big picture' questions become accessible, as befits a science education endeavouring to respond to unprecedented global challenges.

- Whose human interests are being best served and whose are being excluded by current science curricula and pedagogies? And why?
- How can science education embrace authentically the popular ethos of 'science for all' if it does not embrace the 'sciences of all'?
- Why does the paradigm of Newtonian science, with its 'clockwork' (reductionist, deterministic, linear, materialist) view of the universe, continue to prevail in physical science curricula? And in shaping postgraduate research designs?
- What are the distinctively different underlying premises of the 'new sciences' of chaos theory, complexity theory, quantum theory, relativity theory, superstring theory, biocentrism, creative evolution, etc., and how might they contribute to a revitalised science education that aims to develop in students the higher-level

cognitive and social abilities required for addressing the great moral and ethical challenges of the 21st Century?

- How can a 'socially responsible' science education counterbalance the triumphalism of modern science and technology (which are much celebrated on popular tv) with a 'radical humility' born of a deep understanding of the well-documented harmful side effects of the seemingly benevolent use of science and technology to improve the human condition: global warming, natural resource depletion, loss of biocultural diversity, nuclear radiation contamination, unregulated genetic engineering, proliferation of weapons of mass destruction, etc.?
- What human values currently govern the selection (and exclusion) of science curricula content and pedagogies, how well are they justified, what is their use-by-date, are there better alternatives, how are they being canvassed, and by whom?

Coda

As a form of professional development for science educators, transformative learning is inherently democratic and empowering as it makes visible and subject to critical scrutiny the (academic and political) decision-making process and premises that govern (past and future) curricula developments in science education. Transformative learning commits professional science educators to 'making a difference' by having their voices heard in forums that shape future science curricula policy. Transformative learning equips science education practitioners with advanced knowledge and skills to develop students' higher-level abilities for committing to act in ways that seek to promote the diversity of life on Earth.



Keywords

Education for sustainability, transformative learning, transformative research, multi-paradigmatic research, professional development, socially responsible science education

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