CHAPTER 2

Strengthening Environment and Sustainability Subject Knowledge: Curriculum Challenges and Opportunities

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The emerging field of environmental and sustainability science

This chapter serves as a positioning paper for the chapters that follow in which different environment and sustainability knowledge foci will be explored in the South African Curriculum Assessment Policy Statements (CAPS). As a series of interconnected and cross-cutting complexities, environment and sustainability content knowledge has relevance for, and is widely distributed across, different phases and subjects in the school curriculum (see discussion of environmental content knowledge in Schudel and Lotz-Sisitka, Chapter 1; Lotz-Sisitka et al., Chapter 6; Msezane, Chapter 7). Knowledge that makes its way into education curricula and teaching is produced within the wider scientific context. Bernstein (2000), in his theory of the pedagogical device, refers to this as the 'Field of Production'. A significant knowledge-producing community for sustainability concerns is the global change research community (international and national) (South Africa DST 2010). Examining their research outputs and discourses can provide important insights for the development of knowledge in what Bernstein names 'regions', where singular disciplines such as Science (e.g. climate sciences/biodiversity sciences/water sciences/health sciences), come together with other singular disciplines such as education. Bernstein suggests that a first level of knowledge recontextualisation in the Field of Production occurs in these regions (e.g. where environmental educators or science educators recontextualise the knowledge of scientists).

An essential defining feature of environment and sustainability content knowledge in these regions is that it emphasises the interconnectedness and interdependence of human systems within ecological systems, and one of its core challenges is that the 'quality and availability of the planet's ecosystem services, on which human populations depend, are deteriorating, with serious detrimental consequences for social development and welfare, (South Africa DST 2010: 30). In the environment and sustainability sciences, this social-ecological interconnectedness has been illustrated in different ways, for example:

- Modelling of ecosystems and human well-being (Millennium Ecosystem Assessment 2005) or the relations between human social, economic and political systems and the biophysical environment (O'Donoghue 1993; Raworth 2017);
- Ecological limits have been illustrated and measured through modelling of ecological footprints (Chambers, Simmons & Wackernagel 2000) and planetary boundaries (Rockström 2009); and
- Environmental management models such as the drivers-pressures-state of environment-impacts-response (DPSIR) framework for state of environment reporting by the United Nations.

These models, measures and frameworks from the field of environment and sustainability science have helped in illuminating and monitoring the risks associated with interacting forces that arise in a polycrisis of 'intersections between global warming, ecosystem breakdown, resource depletion, the global economic crisis, poverty and urbanisation' (South Africa DST 2010: 7). It is this first level of recontextualisation that is a key knowledge-building space for environment and sustainability education. In this space, there is a need to develop more complex, systemic understandings of reality (Bhaskar 2010; Hadorn et al. 2008; Wiek, Withycombe & Redman 2001). The complex web of knowledge that this space contains and the ontological and epistemological nature of this knowledge also requires inter- and transdisciplinary engagement (Bhaskar 2010; Hadorn et al. 2008).

A second level of recontextualisation occurs as knowledge from regions is recontextualised from the Field of Production into the 'Official Recontextualising Field' where curriculum policies and guidelines are produced. This knowledge includes key themes usually addressed through Education for Sustainable Development (ESD) such as climate change, biodiversity, sustainable production and consumption, global justice, disaster risk reduction, and poverty reduction (Rieckmann 2017). The knowledge from the environment and sustainability sciences is recontextualised (mainly via Education Department officials responsible for curriculum development in consultation with specialist educators in the field) into the national system of education and training. In the case of South Africa, this was strongly driven by the Environmental Education Policy Initiative and the Environmental Education Curriculum Initiative in the contributions of earlier environmental educators to curriculum development (Lotz-Sisitka & Olivier 2001).

In this book, it is the second process of recontextualisation, in the later CAPS curriculum, that was of interest to Makwena Mmekwa and Ingrid Schudel (Chapter 3) who report on the recontextualisation of biodiversity knowledge from key scientific documents in the field of production to the official recontextualising field (the CAPS curriculum). Some of the processes and challenges of the recontextualisation process across the pedagogic device are discussed in the next section.

Processes and challenges of recontextualisation in the South African curriculum

One of the problems created by this recontextualisation into the schooling system is a tension between support for maintaining strong disciplinary boundaries, and integration to support the transdisciplinary understanding mentioned above. The South African schooling system adopted ambitious strategies for integration under the outcomes-based education system. First, integration was supported through the use of ‘phase organisers’ to package curriculum content in Curriculum 2005 (C2005) – of which ‘environment’ was one. Responsibility was placed on teachers to develop their own learning programmes with these phase organisers being one of the complex curriculum design elements they needed to take into consideration. Research in the South African Learning for Sustainability project identified an assumption that teachers would be able to ‘access information and resources and know how to interpret these resources in order to introduce learners to the different dimensions of the issues’ (Lotz-Sisitka & Olivier 2001: 114). Additionally, there was a problem with the assumption that teachers wanted to accept responsibility for curriculum development and design (Lotz-Sisitka & Olivier 2001). Both of these issues made working with phase organisers a challenge within teacher development programmes.

In a later curriculum, the Revised National Curriculum Statement (RNCS), integration was supported through the permeability of disciplinary boundaries (disciplines were organised as ‘learning areas’ rather than strongly bounded subjects) and environmental educators shifted their focus to reconceptualise the way in which environment was being interpreted in and across the different learning areas (Lotz-Sisitka 2002). The environmental education community embraced the opportunities offered by this open curriculum structure, but also acknowledged the challenge that different resources were required in relation to different learning outcomes, and also the different contexts in which learning takes place (NEEP-GET 2005). A resource-based approach to environmental learning (NEEP-GET 2005) resulted in the development of learning support materials themed, for example, around water quantity and quality, waste and biodiversity (Mbanjwa 2001; O’Donoghue n.d.; Raven 2006; Schreuder 2005; Schudel et al. 2000). The NEEP-GET highlighted challenges with the design of these materials such as alignment with curriculum design elements and making the mediation role of teachers clear and explicit (NEEP-GET 2005).

Additionally, there were challenges with the use of the materials. Ramsarup’s case reports of teachers participating in the NEEP-GET programme highlighted a

concern that teachers cannot be assumed to possess the ‘symbolic capital to tease out the environmental learning embedded within ... learning actions’, such as recycling (Ramsarup 2005: 93). Similarly, with the integration of natural resource management in official Life Sciences curriculum documents, Nsubuga argued that certain contexts (such as rural isolation) create greater conceptual and practical ‘distance’ between the official curriculum documents, their interpretation by teachers and their implementation in classrooms. Resource-based or knowledge-based challenges among teachers, she argued, could affect the implementation of such integration opportunities in classrooms (Nsubuga 2008). All of these problems contributed to difficulties in working with an integrated and theme-based approach to environmental learning.

The next iteration of the National Curriculum Statement (NCS) included three documents: *The Curriculum Assessment Policy Statements* (CAPS), a national policy pertaining to the programme and promotion requirements of the NCS Grades R–12, and a *National Protocol for Assessment Grades R–12* (South Africa DBE 2011c: i). The CAPS heralded a strong return to the disciplinary boundary and a reinstating of disciplines as bounded subjects (South Africa DBE 2011c). This is a central epistemological ‘tension’ that this chapter explores in more depth (see Vignettes 1 and 2 that follow). Despite these challenges, the Fundisa for Change programme, underpinned by this new curriculum, began working with and expanding on environmental content specific to each bounded subject (Fundisa for Change Programme 2013). This expanded content is one aspect of what the Fundisa for Change Programme refers to as a CAPS++ approach to environmental learning. This book details broad-scope research into subject-specific topics, namely that of Heila Lotz-Sisitka et al. (Chapter 6) who explore the representation of climate change content knowledge in the CAPS, and Sikhulile Msezane (Chapter 7) who explores the extent of the representation of environmental content in all subjects in the Grade 12 curriculum and examinations. Additionally, the book reports on detailed research of specific topics in specific subjects, namely that of Dorelle Isaacs and Lausanne Olvitt (Chapter 4); Makwena Mmekwa and Ingrid Schudel (Chapter 3) who focus on the topic of biodiversity; and Gavin Heath and Rob O’Donoghue (Chapter 5) who focus on water catchment management.

A second problem created with recontextualisation of environment and sustainability content in the South African CAPS is that it has resulted in ‘fragmented representations’ of environmental knowledge in the form of topics that cross a range of schooling levels and subjects, and these appear to have been put together in a manner that lacks conceptual coherence, progression or a clear overall epistemological and/or pedagogical framework (Songqwaru 2012; see also Lotz-Sisitka and Mandikonza, Chapter 6 in this book). As reported by Songqwaru and Shava, this lack influenced the focus of the Fundisa for Change programme, which teachers reported as enlightening them regarding ‘conceptual progression and connections within and across the grades’ (2017: 216).

A third problem of recontextualisation can occur as it is relocated from applied fields where knowledge is constructed for addressing environment and sustainability

needs in particular contexts. Wiek, Withycombe and Redman indicate the applied nature of environment and sustainability knowledge in their explanation that:

The field's development is a response to existing and anticipated complex problems including climate change, desertification, poverty, pandemics, war – all featuring high degrees of complexity, damage potential, and urgency, and all having no obvious optimal solution. To solve these and other 'wicked' sustainability problems, the field generates, integrates and links use-inspired knowledge to transformational action in participatory, and adaptive settings. (2001: 203)

As Bernstein explains, 'unmediated discourses [applied discourses in the field] are transformed into mediated, virtual or imaginary discourses [in more or less strongly bounded disciplines]' (Bernstein 2000: 33). As knowledge is relocated it can become disembedded from, and lose, its spatio-temporal context: that is, it can lose its historicity, cultural roots, and resonance in specific geographic locations and scales as they range from local to global. It is textbooks and learning support materials, and their appropriate selection for specific needs, that play an important role in re-embedding abstracted knowledge as it is taught in classroom contexts. Studies of environmental learning in the RNCS that have explored these challenges include those of Ramsarup (2005) and Nsubuga (2009). This potential problem with recontextualisation links closely to a tension about the relationship between discipline-based and everyday knowledge, and even though the CAPS' strong discipline-based approach has tended to downplay the importance of everyday knowledge, this chapter argues for its importance for environmental learning: that is, through the discussion of knowable and situated knowledge as it emerges from Vignette 3.

The re-embedding of abstract knowledge needs to occur by re-connecting with the spatio-temporal roots of the knowledge, but also through projecting into possible contemporary and/or future spatio-temporal resonances. This is where the transformative and visionary potential of environment and sustainability knowledge becomes important. For example, O'Donoghue reports on situated learning processes in which 'participants engaged in matters of concern and developed intervention experiments towards change projects that were sustained, narrated and shared as transgressive learning and innovation towards a sustainable future' (O'Donoghue 2017: 27).

However, supporting the construction of transformatory and visionary knowledge raises a fourth problem for recontextualisation in a national curriculum and that is how to introduce learners to cutting-edge ideas and practices such as alternative globalising economic thinking (Raworth 2017), or alternative local farming practices (Machobane & Berold 2003), without imposing pre-determined behaviours for learners – an approach to ESD which has substantive critiques (O'Donoghue & Lotz-Sisitka 2002; Lotz-Sisitka & Schudel 2006). A resource that directly addresses this problem is the *Handprint Action towards Sustainability* series produced by O'Donoghue and Fox (2009). This series illustrates case studies of local learning and situated stories of change in real

contexts. Such materials are important for illustrating sustainability practices that can be trialed and adapted for different contexts. These materials are representative of the third level of recontextualisation that occurs in Bernstein's pedagogical device: that is, the Pedagogic Recontextualising Field (Bernstein 2000) where knowledge is further recontextualised by the development, selection and adaptation of textbooks and other materials to support teaching and learning as outlined in the curriculum. Vignette 5 in this chapter is an illustration of another such set of materials supporting transformative and visionary knowledge construction.

Another process that occurs during recontextualisation as explained by Bernstein is that: 'No discourse ever moves without ideology at play. As this discourse moves, it is ideologically transformed' (Bernstein 2000: 32–33). Particularly for ESD, and in the light of the 'new normal' sparked by the COVID crisis, there is a need 'to trigger structural transformations in today's economic and social systems by promoting alternative values and contextualised methods' (Unesco 2020: 9). In the outcomes-based schooling systems (as adopted in C2005 and the RNCS), a principle highlighting the importance of paying attention to the relationship between human rights, inclusivity, and environmental and social justice was an explicit ideology underpinning both curricula. This principle is an important driver for integrating ESD as an 'holistic approach to reshaping education to address sustainability challenges' (Unesco 2020: 47). Yet, from research in the context of training with teachers, Ramsarup noted that the principle was interpreted in a reductionist manner, with inclusivity discourse dominating training materials and interpretations by educators. This, she found, was 'threatening the holistic engagement with the first principle', 'ideologically driving the recontextualising of the first principle' and 'subsequently narrowing the policy discourse and its intent' (Ramsarup 2005: 99). The two post-apartheid curricula emphasised the importance of knowledge (in the narrow sense of the word, simply meaning curriculum content), skills and values, thus highlighting the importance of the cognitive, psychomotor and affective domains of learning. It is particularly around the 'values' aspect of learning that one would expect this principle to come into play, yet if the principle is not fully understood or embraced, then one would not expect meaningful environment and sustainability values deliberations to emerge in classroom contexts.

The CAPS curriculum has the same basic principle underpinning all subjects, but no longer emphasises 'values' as an explicit aspect of learning. Ramsarup's research illustrates that an isolated principle does not guarantee infusion into specific subjects and topics. This raises the question of how much this principle has influence in CAPS-driven knowledge practices today, especially given that values are no longer highlighted, and thus potentially undermining the affective domain of learning. Ramsarup's research underpins the fifth and final problem of recontextualisation introduced in this chapter, and that is that values driving the environment and sustainability sciences in the Field of Production might become less and less explicit as they are taken up in the fields of official and pedagogic recontextualisation. This is equally true for critical engagement with these values, if curricula do not explicitly provide content that necessitates such

engagement. The role of values in the CAPS curriculum is explored in Chapter 4 of this book by Dorelle Isaacs and Lausanne Olvitt. Their chapter considers the different ways in which teachers see biodiversity as possessing either intrinsic value, or value to humans as a resource. Vignette 4 in this chapter further supports the argument for the importance of explicitly working with the values-based underpinnings of environment and sustainability knowledge.

In the light of the five problems with recontextualisation identified above, five vignettes are presented below that draw on the authors' experiences of working with environmental and sustainability content in a variety of teacher education programmes. At the same time these vignettes illustrate particular characteristics of environmental knowledge across a variety of subject disciplines and school levels.

Working with environmental and sustainability content knowledge

Deepening knowledge and increasing rigour through laminated systems with specialist foundations

The previous section discussed how the CAPS curriculum has been structured around strongly bounded subjects. As subject specialisation increases, the challenge for environmental learning is how distinct content across a laminated science and social sciences system can support understanding of environmental sustainability. This includes understanding life-support systems and processes, social and economic systems, and personal and social well-being that are all part of a holistic understanding of environmental issues and risks.

Specialised disciplines give us access to different laminations of reality (such as different specialisms in the sciences and social sciences) as described above. Additionally, specialisms provide us with different ways of accessing and describing that reality: that is, different languages for describing reality. Not only is descriptive 'know that' propositional knowledge required, but also 'know how' procedural knowledge (Bertram 2009; Muller 2014: 263). The latter is concerned with knowing how we come to know. Specialist subject knowledge requires attention to both of these. For example, the sciences and (more rarely) the social sciences might make use of experimentation in closed systems; or, both sciences and social sciences might make use of descriptive modelling, for example, describing ecosystems and well-being as in the international Millennium Ecosystem Assessment (2005) elaborated in the introduction to this chapter.

Mathematics might give us a strongly quantitative way of describing reality, or systematic ways of visualising reality; while the arts might use metaphor, analogy and images. Environmental learning requires a combination of these different laminations and languages in order to give the most complete picture and to find, triangulate and make judgements on claims of truth.

The vignette below illustrates environmental learning in which the sciences and social sciences are employed in creating a laminated holistic social-ecological perspective

on bees in the Foundation Phase classroom while deepening and strengthening these perspectives through mathematics and languages.

Vignette 1: Cross-curricular, bee-themed lessons for Foundation Phase schooling

In a demonstration of theme-based curriculum planning, Foundation Phase pre-service teachers are introduced to a series of Grade 3 cross-curricular lessons on bees with an environmental focus. The lessons are driven by the Life Skills subject but also draw on mathematics and language skills in developing and deepening understanding. Lessons cover bees and other insects and how these play different roles in their relations with humans (at times helpful and at times harmful). This, together with a humorous poem about a mosquito that bites boys' bottoms and another poem titled 'Don't bother any butterflies' is intended to help address fears learners might have about insects and other 'creepy-crawlies' while developing a healthy respect for certain situations in which relationships between humans and insects might prove harmful on both sides (English Home Language lesson).

Mathematics and a focus on 'line of symmetry' helps learners to look closely and to see and describe with more detail and accuracy. Lessons also cover the science of how bees make honey and help to pollinate flowers – many of which belong to plants that go on to become food for humans. Further lessons are intended to develop respect for bees: first through an emphasis on how hard a bee needs to work in order to make a single drop of honey, and second through a focus on how bees make use of the best shape for making their honeycomb (both of these are predominantly Mathematics lessons). Other lessons are intended to develop empathy through a focus on how water, land and air pollution affects bees and other insects, for example, through lessons focusing on how a water strider would drown if trying to 'walk' on water polluted with soap; how important scent is for bees and how air pollution might affect this; and how long some waste takes to break down (using the procedural knowledge of experimentation in the sciences). Additionally, there is a lesson developed around a story in which a greedy king accumulates vast amounts of gold from the Earth and forces bees to make exorbitant amounts of honey for him to eat. He gets his comeuppance when the bees rebel and the Earth splits and swallows him into its lava centre. This Home Language lesson highlights the problem of exploitation of Earth's resources by human beings. Finally, there is a lesson in which learners are supported to try out environmentally friendly gardening practices in order to encourage helpful insects to visit their gardens.

The benefit of environmental learning in the Life Skills subject is that specialisation into different science and social sciences subjects has not yet occurred in the first three

years of schooling. Bhaskar and Danermark's (2006) notion of a laminated system can give us insights into the different types of knowledge that are combined in this Life Skills subject and that would be needed in order to more fully understand a particular phenomenon. These authors describe a laminated system as 'a system that refers essentially to several different levels of reality' (Bhaskar & Danermark 2006: 280). An example of the use of this system for discussing a particular topic is suggested by Lacey and Lacey's reflection on the laminated nature of seeds as:

(a) Biological entities: under appropriate conditions they will grow into mature plants from which (e.g.) grain will be harvested. (b) Constituents of various ecological systems. (c) Entities that have themselves been developed and produced in the course of human practices. (d) Objects of human knowledge and empirical investigation. All these need to be considered when investigating risks and the potential of alternatives. (Lacey & Lacey 2010: 193)

These laminations of reality can be determined in the particular context of study. For this study, five laminations have been used as identified in Figure 1 below. This figure demonstrates how the bee-themed lessons described in Vignette 1 touch on these five laminations of reality.

Figure 1. Positioning bee-themed lessons within a laminated system

Figure 1 shows the role of the different sciences (Chemistry and Life Sciences) and social science specialist subjects (Human Geography, Economic and Management Sciences, Life Orientation) in enabling a fuller understanding of the interdisciplinary and laminated nature of environmental and sustainability knowledge. The embedded

nature of the diagram is also significant – illustrating that to understand each lamination you need to understand that it emerges from the previous level. For example, without healthy life support systems farming systems cannot be successful.

The vignette also provides insight into the important role that Mathematics and Languages play in providing the power of description, power of persuasion and power for imagining new ways of doing and being. Mathematics is used to help learners develop a keenness of eye, and a sense of wonder about insects using numbers and shapes. Language is used to describe and detail as well to critique, question and re-describe.

Transcending disciplines through transdisciplinarity

The preceding vignette has demonstrated the importance of specialist knowledge. It is equally important, however, not to allow subject specialisation to lead to epistemic monocultures and atomisation (Schudel 2017; Tikly et al. 2020) in which we are denied a full picture of environment and sustainability challenges. For example, O'Donoghue, Kibuka-Sebitosi, Tshiningayamwe and Palmer explain how much of the environmental knowledge 'appropriated from indigenous peoples and their knowledge practices has come back to us in scientific disciplines and curricula [epistemic monocultures] but in such a form that the "Africanness" is not easily recognised and identified with' (O'Donoghue et al. 2019: 5). Additionally, they argue that 'abstract propositions (reified and disembedded perspectives) such as biodiversity and climate change ... are difficult to relate to the intergenerational lived experience as felt sustainability concerns of the day' (O'Donoghue et al. 2019: 2).

Modern curricula need to be able to offer both depth and detail for nuanced understanding of environmental challenges and sustainability practices, while ensuring that boundaries are not too strictly drawn, so that dialogue between knowledges and disciplines can ensue. For example, dialogue between disciplines is critical for the CAPS human-rights-based conceptualisation of environmental health and social justice, as evidenced in the generic curriculum principle which respects 'human rights, inclusivity, environmental and social justice' (South Africa DBE 2011c: 6), as discussed in the introduction of this chapter.

Different disciplines enable different perspectives on phenomena, thus giving depth and rigour to understandings of complex problems. This 'multi-disciplinary' approach may still need important cross-cutting considerations to help draw the different disciplines together. Such cross-cutting considerations can transcend the specific topics identified by independent subject disciplines, thus providing a more holistic perspective on the complexities being considered. Examples of this can be seen in the work by Murray (2005) in the analysis of the Namibian curriculum, where natural resources and their management, poverty and inequality, society and governance, development and the environment, health and the environment, and globalisation were identified as cross-cutting themes in the curriculum. Similarly, Lotz (1996), identified cross-cutting themes in an action research project with primary school teachers, where they developed a series of materials to support Foundation Phase learning. In these materials the group

identified the following themes: understanding the patterns of change; discovering how living things fit into their surroundings; cause and consequence; conservation action to make the world a better place; interrelationships and interdependence; diversity; and place.

When working with complex environment and sustainability knowledge in curricula, the challenge is finding, highlighting and deepening these cross-cutting concerns and making them an explicit focus in classroom deliberations. The next vignette highlights how environment and sustainability topics require teachers to apply such cross-cutting thinking in order to fully understand social-ecological nuances in different contexts.

Vignette 2: Introducing indigenous knowledge in order to understand human impact

In the 'Human Impact on the Environment' topic in the Life Sciences CAPS curriculum, Grade 11 learners need to explore 'indigenous knowledge systems and the sustainable use of the environment, e.g. devil's claw, rooibos, fynbos, the African potato (*Hypoxis*) and Hoodia' (South Africa DBE 2011b: 52). Hoodia, which was used by indigenous African people – the KhoiSan – to treat indigestion and minor infections, is now widely employed as a natural appetite suppressant to support weight loss in modern societies. Rooibos, a tea that was used for many centuries by indigenous African peoples, is now a widely cultivated commercially sold tea available around the world. These cases raise questions about the appropriation of indigenous knowledge by foreign pharmaceutical and health food companies and the rights of indigenous people to own and benefit economically from their own knowledge. The widely publicised cases of indigenous communities' attempts to gain intellectual property rights over these plants and to cultivate and commercialise them, raise stimulating and challenging questions in classrooms around healthy alternatives, cultural and biological heritage, dignified work opportunities, work for women, stimulating local economies, resilient alternative practices in the face of climate change, and responsible agricultural practices.

The cases discussed in Vignette 2 illustrate that not only does environment and sustainability knowledge require a laminated and disciplinary understanding of reality, but also gives a sense of the many cross-cutting concerns that span debates in environmental discourse and which transcend disciplinary boundaries. The notion of transdisciplinarity used in this chapter is influenced by Bhaskar's explanation that transdisciplinarity requires 'new concepts, theories and modes of understanding. This will necessitate epistemological transdisciplinarity, involving the exploitation of pre-existing cognitive resources drawn from a wide variety of [antecedently] existing cognitive fields in models, analogies, etc.' (Bhaskar 2010: 6). This is a notion

distinctly different from interdisciplinarity, which provides a cumulative perspective from different disciplines, rather than a perspective that transcends the limitations of disciplinary boundaries.

The Sustainable Development Goals (SDGs) (United Nations 2015) are a useful frame for illustrating how certain topics, even if in one specialised subject, can require a sophisticated and transdisciplinary perspective on the world. Figure 2 illustrates how cases of indigenous knowledge and its responsible (or irresponsible) use can be brought into play across many of the sustainable development goals: good health and well-being; life and living; gender equality; climate action; responsible consumption and production; sustainable cities and communities; and decent work and economic growth.

Sustainable Development Goals

Figure 2. Transcending disciplines through an SDG framing of social-ecological interactions

Environmental knowledge as knowable and situated

If environmental knowledge has the kinds of complexities described above, then we are faced with the danger of becoming so unsure about how to describe a complex world that we cannot take decisive action to change that world for the better. Complex social-ecological systems require the capacity to identify rigorous scientific principles, beyond a narrow and positivist perception of science and social science.

Vignette 3 illustrates how people can become divided over the facts, figures and realities of environmental concerns, thus highlighting the need for spaces in curricula for debating the rigour of environment and sustainability content in curricula.

Vignette 3: Interview between a climate change denialist and a ‘science guy’

One of our activities exploring the nature of science introduces science education students to an interview between Fox News Channel presenter, Tucker Carlson, and Bill Nye, popularly known as ‘Bill Nye the Science Guy’. This interview illustrates how a narrow perspective on science can be manipulated to defend climate change denial.

Carlson opens with a welcoming statement: ‘We are coming to you live from outside the US capitol building where President Trump will address a joint session of Congress in fewer than 24 hours. You may hear construction noise behind us during the show. That is because there is construction going on. There always is in Washington. The richest city in America. And we want to thank you for that. For sending your tax dollars here. It’s built a pretty nice place.’ Moving to his interview with Nye on climate change he asks: ‘Why the change? Is it part of the endless cycle of climate change or is human activity causing it?’ When Nye answers that climate change is definitely caused by humans, Carlson aggressively insists: ‘I am asking a very precise question. To what degree is climate change caused by human activity. Is it 100% of climate change that is caused by human activity? Is it 73.4%? If it is settled science, please tell us to what degree.’ Nye does not answer this question because to try and do so in an open system would be nonsensical and unscientific. He replies: ‘The word “degree” is a word that you chose.’ Nye highlights repeatedly that it is the rate of change which is unprecedented. Carlson then insists on knowing to what degree the **rate of change** is caused by humans. Exasperated, Nye answers: ‘100%. If that is the number you want.’ Fixated by numbers, Carlson then asks: ‘Without human activity how long would it have taken for us to have reached this level of warmth in our climate?’ It is impossible to answer this nonsensical question, which puts ‘us’ into a scenario in which we are trying to establish what would have been different without ‘us’. Nye replies: ‘It’s not clear that it would have happened. In other words, humans have changed the climate so drastically that we have avoided another Ice Age.’

Failing to win the numbers game, Carlson then insists on knowing **when** the Ice Age would have started if it hadn’t been for human activity, to which Nye replies by stating that the question is irrelevant. Arguing constantly for specific figures and precise times, which no science based on modelling in open systems would ever claim, Carlson is appearing to fall back on one of his opening remarks that: ‘The essence of science is extreme skepticism.’ His extreme skepticism is so extreme that it disallows the use of the best available data to attain the best possible description of the truth.

Having failed to out-argue Nye up to this point, Carlson changes tack and asks something less quantitative and more qualitative: ‘What would the climate look like, right now, without human activity?’ When Nye answers with a long

list of examples of agricultural and ecological systems that have been disrupted by climate change since the 1750s (the beginning of the industrial revolution), Carlson finally loses control of the interview, angrily retorting: 'You don't actually know because it is unknowable' and following later with 'So much in this you don't know. You pretend that you know. But you don't know. And you bully people that ask you questions.' He ends with 'I am open-minded. You are not. And we are out of time unfortunately.'

How is this intense divide on climate change that is played out in the vignette possible? I suggest that one reason (the next will be discussed in the next section) is simply bad science. No good science would claim that our knowledge of the world is in direct correspondence with (an exact replica of) the world. This is supported by a critical realist view of science which acknowledges that 'there is no way of knowing the world except under particular, more or less historically transient descriptions' (Bhaskar 2009: 99). Scientific modelling can only be based on the best available data to attain the best possible description of the truth. To throw out an extensively well-researched explanation of climate change because of an insistence on exact figures shows limited understanding of the powers of science, and restricts science's capacity for qualitative descriptions of the world. To throw out well-researched explanations of the effects of climate change because they are 'unknowable' as claimed by Carlson, is problematic. 'Knowability' is a complex dilemma. We cannot know everything that has happened in the past, nor can we fully know the status quo, because we rely on selected data and limited sets of data. Neither can we accurately predict the future – predictive models can never be completely knowable because they are in the future.

Drawing on a critical realist perception of knowledge, Scott (2013: 9) explains that: 'Knowledge is always fallible, and this applies equally in cultural, epistemological or practical settings. As a result, fallibility cannot just be equated with inadequacy or insufficiency, but also implies that no epistemic certainty can be guaranteed.' This means that we can (and must) use the best available data to describe climate trends through modelling techniques. Equally, we must use our laboratory-based knowledge of the greenhouse effect to gain a basic understanding of the physical and chemical powers that are capable of driving these climate change trends. Price explains that by their very nature, ecological models can never entirely be proven, but that 'rather than denying the truthfulness of their models, ecologists would be better off explicitly embracing transcendental realism' (Price 2019: 34). Transcendental realism acknowledges that there is more to what is 'real' than what is experienced. The empirical evidence gathered by science over time to explain the warming power of greenhouse gases is sufficient to argue that this same power will be exerted on a planetary scale and have real effects in terms of global warming.

Additionally, when empirical evidence of change is found (e.g. the qualitative stories presented by Nye of changes affecting local economies) then this evidence highlights the urgency and seriousness of climate change predictions, even if the

measured changes are not a direct match to the predicted changes. ‘Knowing the world’ is not only about numbers and modelling, as Vignette 2 demonstrates. Situated knowledges, which need to acknowledge ‘stakes in location, embodiment and partial perspective’ (Haraway 1988: 584) are critical places to start with making decisions on which we can act. Haraway furthers her argument by saying that unlocatable knowledge is irresponsible knowledge (1988). Unlocatable knowledge is another form of bad science. We see the importance of these situated knowledges in the located and embodied stories Nye tells of climate change effects which are demonstrated in the non-suitability of certain places for crops; the persistence of pests; and changing snowlines (with economic consequences for farmers and local communities – on which extended narrative could elaborate).

Climate models highlight change and uncertainty with a trend towards negative consequences. Common sense would dictate that we do not wait for such trends to be fully proven (even if this were possible) before we heed their warnings – since by that time it would be too late anyway to act (Price 2018). What we need is enlightened common sense as inspired by Bhaskar’s critical realism, which insists on ‘a serious philosophy that we can act on, and one moreover that is relevant to the pressing challenges we face and that ideally at least can illuminate a way forward’ (Bhaskar 2016: 2).

Explicitly values-based

In the previous section, it was suggested that one reason for the intense divide on climate change is ‘bad science’. Another is conflicting ideologies. Unesco describes a study ‘in which policy documents of ten countries shows that ESD is mostly associated with the teaching of scientific knowledge on environment. This is not enough to bring the transformative power of education to its full force’ (2020: 9). This same document suggests that one aspect of learning includes the social and emotional, for which it is necessary to ‘build core values and attitudes for sustainability, cultivate empathy and compassion for other people and the planet, and motivate to lead the change’ (Unesco 2020: 17). It is for this reason that environmental content must be presented in such a way that ideologies can be uncovered and deliberated. The situated stories told by Nye are a stark contrast to Carlson’s introductory remarks in his show, in which Washington DC, completely dislocated from the local economies affected by climate change, is painted as a ‘nice place’ built by the taxes from these distant economies. The question for environmental educators then becomes: How do we make judgements on which to build environmental actions? A ‘nice place built by taxes’ appears to be used by Carlson to suggest, before the interview even begins, that any argument for reduction in carbon emissions could jeopardise the comfortable capitalist economy that creates the wealth and splendor underpinning America’s seat of power.

Critical realism insists that phenomena need to be described using ontological realism (the real possibility of the greenhouse effect leading to global warming), epistemological relativism (the real possibility of different interpretations of reality by different people such as Carlson and Nye) and judgmental rationality (the real possibility

that certain interpretations of reality are either untruthful misrepresentations of reality, selectively descriptive or simply manipulative to serve a particular cause). The three tools of ontological realism, epistemological relativism and judgmental rationality are described in first wave critical realism (Bhaskar 2016).

To better understand rational judgement we draw on both critical realism and situated knowledges, although this may be problematic for some who argue that the notion of situated knowledges is not entirely commensurate with critical realism. There are two reasons suggested for this schism: first, the suggestion that critical realism fails to acknowledge that judgmental rationality itself requires situated judgmental rationality; and, second, a suggestion that critical realism's insistence on generalisability is problematic (Smirthwaite & Swahnberg 2016).

Yet Bhaskar's second-wave dialectical critical realism and the notion of the concrete universal helps to resolve both of these concerns. A concrete universal approach to ethics is one that is considerate of universal rights and freedoms, dynamic and changing, holistically considerate of implications for all, and context-sensitive in the sense that 'all individuals, though sharing a common humanity, [are treated] as ethically different' (Hartwig 2007: 74). This suggests that there are general or universal perspectives which can be proposed and emphasised, but that is only if all humans (and all other life forms) are treated respectfully and with sensitivity to their contextual needs and realities. This is not intended to recommend a relativist approach to knowledge, which values all knowledges as equally valid, nor to posit simplistic integration of incommensurate knowledges. It is important not to make the mistake, as Haraway says, of 'easy relativisms and holisms built out of summing and subsuming parts' (1988: 585). In other words, a response to Smirthwaite and Swahnberg's concerns is a notion of *situated* and *ethically defensible* generalisability.¹

The notion of concrete universality (or situated and ethically defensible generalisability) can be usefully employed in processes of situated judgmental rationality. Thus, a 'nice place built by taxes' can only be considered to be nice if the economies that build it are nice to ecosystems, nice to small-scale farmers, nice to vulnerable economies, and more. Such 'niceness' might be termed 'sustainability' – a universal right or freedom that environmental educators can subscribe to. Environmental knowledge is explicitly values-based and needs these tools to make judgements in order to guide future action. This notion can be seen to be consistent with Haraway's conception of situated knowledges, which she describes as 'positioned rationality' requiring '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 with limits and contradictions' (1988: 590).

The next vignette illustrates the importance of being able to draw on the notion of concrete universals in ethics deliberations when instances of oppression and exploitation are represented in curriculum content.

1 Neither generalisation nor universalism should be confused with totalisation. Haraway argues that both relativism and totalisation deny the 'stakes in location, embodiment, and partial perspective' (1988: 584). Thus, both relativism and totalisation, as defined by Haraway, are unhelpful positions for representing environmental content in curricula.

Vignette 4: *Exploring sustainable development in the Geography curriculum*

The following are extracts from a Grade 12 Geography textbook used in South African classrooms, in which mining was discussed under the topic of Economic Geography. The topic is opened with an extract from a newspaper describing an internationally reported case of strikes and violence at Lonmin's Marikana platinum mine in South Africa. The article notes the 'high cost' of these incidents, namely 44 deaths, many of which occurred when police opened fire on workers demanding higher wages. The article moves on to explain that as strikes spread to other mines, they could have wider financial ramifications for South Africa. The major part of the article goes on to discuss loss of investor confidence and effect on the GDP.

The textbook then continues with a bullet list of the following 'Challenges to mining':

- Climate: high temperatures in areas such as Hotazel and Kuruman make mining very difficult, as costs of cooling the mineshafts are high.
- Distance: large distances between the mines and the harbours or towns have increased costs.
- Foreign dependency: we need overseas buyers, as only 15% of our minerals are sold locally.
- Labour: high costs in training and housing, as well as strikes and tribal fighting, have all affected productivity.
- Water: water shortages and underground water flooding are real problems.
- Price: if the price of gold drops, mines close and jobs are lost.
- Minerals: these are non-renewable resources. In some mines, the minerals have been exhausted.
- Accidents: explosions and the collapse of tunnel roofs cause loss of life and skills.

In Vignette 2, discussion centred around some of the cross-cutting themes that emerge within environmental discourse. Sustainable development (or 'environment and development', as in the Namibian curriculum analysis described in the above section on transdisciplinarity) is one of the cross-cutting themes that can be found in the CAPS curriculum in different subjects and phases, linked to topics such as: natural resource management and sustainable use (Economic and Management Sciences, and Social Sciences); responsible use of mineral resources (Technology, Natural Science, and Economic and Business Sciences); renewable energy (Natural Sciences and Technology); impact of development on environment (Agricultural Sciences, Technology, and Economic and Management Sciences); and waste management (Natural Sciences and Business Sciences). In Geography Grades 10–12, the focus on sustainable development

intensifies with critical exploration of the concept of development, from the perspective of economic, social, sustainable, appropriate scale and spatial aspects; to modelling of different frameworks for development including 'sustainability models with their economic, social, and environmental elements', and a focus on limits to development such as natural resource limitations and environmental degradation (South Africa DBE 2011a: 34).

Vignette 4 is in stark contrast to the sustainability principles highlighted in these Geography curriculum intentions. Sustainability discourse requires a perspective on economics that includes social-ecological relationships. Yet, the section on economics, in this textbook, takes the position of a lopsided, solely economic representation of an extractive human-environment relationship – namely mining. Environmental concerns are limited to 'resource restrictions' and social issues are undermined to the point where even 'loss of life' is couched, together with 'loss of investor confidence' and 'loss of skills', as an economic concern. This tendency for economics to overshadow critical sustainability concerns is not surprising given the acknowledgement by Unesco that,

There is wide agreement that it is challenging to reconcile economic growth with the principles of sustainable development, as far as current industrial and production patterns continue. Ever accelerating production and consumption deplete natural resources, produce unmanageable amounts of waste and lead to a rise in global temperatures. (Unesco 2020: 58)

Both Vignette 4 and the Carlson/Nye debate in Vignette 3 highlight that when different perspectives on science and different ideologies collide, it becomes hard to achieve consensus on the way forward. Irresponsible knowledge needs to be recognised and named, as do ideologies that underpin oppressive or exploitative relationships. Only then will we be able to find, or better still, create, situated stories that are capable of 'sustaining the possibility of webs of connections called solidarity in politics and shared conversations in epistemology' (Haraway 1988: 584).

Transformative and visionary

The preceding two vignettes highlighted the need to name and oppose oppressive and exploitative relations in an ideologically explicit way. Bhaskar refers to such relations as Power 2 relations, constituted by 'exploitation, domination, subjugation, oppression, repression and control' (Bhaskar 1993: 176). The judgmental rationality engaged in order to critique these relations is important to contrast with a relativist 'anything goes' outcome in environmental deliberations. This is because relativism 'leads to the inability to act, since how can we act if we cannot choose between better or worse?' (Price 2007: 107). Once clearly untenable relations are named, the transformative imperative of environment and sustainability content in curricula is foregrounded. The following vignette describes a teaching pack used to explore 'carbon footprinting' – a significant sub-topic under the theme 'Human Impact' in the South African Life Sciences (the

same topic discussed in Vignette 2). It is significant because, out of 34 sub-topics listed under 'Human Impact', this is one of only four sub-topics that specifies or implies the need for alternative practices. This need for alternative practices is suggested by the 'concept of "carbon footprint" and the need to reduce the carbon footprint' (South Africa DBE 2011c: 51).

Vignette 5: Using footprinting to support transformative and visionary knowledge practices

A footprinting pack named 'The African Ecological Footprinting Game', developed by the Environmental Learning Research Centre, was commissioned by the Danish international aid organisation (IBIS). The pack has been used with Life Sciences pre-service teachers to address the curriculum sub-topic of carbon footprinting.² This pack has a series of information sheets and activities as follows:

- Information sheets that discuss the significant components of an ecological footprint, namely, energy, materials and waste, food, living space, travel, water and biodiversity. The information sheets also highlight the realities and specificities of a footprint in an African context.
- A set of nine question cards, which are used to calculate the carbon footprint and reflect on the broader ecological footprint. The footprint calculates the square area of land or sea needed to sustain an individual or country with the resources consumed and to absorb the waste produced. This is then compared with the amount of available land and sea if this was equally divided among all the people on Earth (with 'sufficient' area set aside to preserve ecological biodiversity).
- A set of 'Think About' cards, which are intended to stimulate discussion around environmental sustainability, especially issues regarding social and environmental justice and ecological health.
- A set of 'Action Option' cards which suggest individual and systemic options that might be considered for reduction of a carbon footprint.
- A collection of resources with ideas for, and case studies of, alternative sustainability practices.

The activities described in the vignette highlight the ecological limits of the planet, which humans are exceeding, and the inequalities and environmental injustices associated with exploitation of natural resources (thus deepening environmental knowledge). They critically examine some of the contextualised complexities and

² Ecological footprinting is a broader concept than carbon footprinting, and the described pack covers the detail of carbon footprinting and elaborates to consider other ecological impacts of human activity.

trade-offs associated with sustainable development (strengthening situated knowledge and capacity to critique values and lifestyle choices), and explore both individual and systemic alternatives to support the capacity to 'live lightly' on the Earth (strengthening visionary and transformative knowledge).

The latter requires the ability to move beyond simple 'impact' – a Power 2 relation between humans and their ecological foundations. It entails an exploration of alternative Power 1 relations as posited by Bhaskar and described by Hartwig as:

The general causal powers of human agency whose characteristics entail the possibility of human emancipation, such as our capacity to investigate, communicate, plan, construct moral and ethical systems, feel and care for others, and come to agreement based on judgmentally rational argument directed at practices that transform our lived circumstances. (Hartwig 2007: 372)

The resources described in the vignette with ideas for and case studies of alternative sustainability practices provide important situated stories of change such as are seen, for example, in the *Handprint Action towards Sustainability* series described in the introductory section of this chapter. The importance of supporting visionary knowledge at the schooling level is highlighted by ESD's dependence on the role of youth in change practices and Unesco's suggestion that,

it is young people who are becoming increasingly vocal and active, demanding urgent and decisive change and holding world leaders accountable, in particular to address the climate crisis. They have, and continue to envision, the most creative and ingenious solutions to sustainability challenges. (2020: 32)

We suggest that for modern curricula to have relevance for the youth of today, they need knowledge resources that can support and guide this creative energy.

Conclusion

This chapter has noted the social-ecological and complex nature of environment and sustainability content knowledge. It has highlighted problems arising in the recontextualisation of this knowledge from its transdisciplinary site of production, to the creation of a strongly discipline-bounded curriculum, to its interpretation, mediation and facilitation by textbook and materials developers. The five problems of recontextualisation discussed in the chapter are:

- Tension between support for maintaining strong disciplinary boundaries, and integration to support the transdisciplinarity that is key to environment and sustainability understanding.

- Fragmented representations of environmental knowledge in the form of topics that cross a range of schooling levels and subjects.
- As knowledge is relocated it can become disembedded from and lose its spatio-temporal context and, subsequently, its potential for meaning-making and application to urgent contemporary environment and sustainability problems.
- A change orientation is complex for a national curriculum, but needs to include cutting-edge ideas and practices such as alternative globalising economic thinking or alternative local farming practices.
- Values driving the environment and sustainability sciences might become less and less explicit as they are taken up in official curriculum and pedagogic discourse – as might critical engagement with these values if curricula do not explicitly provide content that necessitates such engagement.

The vignettes highlighted some thinking tools to help ESD practitioners to strengthen their knowledge practices. Laminated systems were used in response to the first vignette to illustrate how different disciplines can be used to explore environment and sustainability phenomena without conflating subject disciplines (a response to Problem 1). The SDGs were used in response to the second vignette to show how cross-cutting concerns can be brought together around particular environment and sustainability topics (a response to fragmentation described in Problem 2). The response to the third vignette used the notions of situated knowledges and the concrete universal to demonstrate how environment and sustainability can and must be ‘knowable’, and also how it can be situated in local and global contexts (a response to the problem of spatio-temporal disembeddedness described in Problem 3). The fourth vignette highlighted the importance of explicit values-based orientations to knowledge construction (a response to Problem 5). Finally, the fifth vignette illustrated the importance of content knowledge that enables Power 1 relations in response to oppressive Power 2 relations (a response to Problem 4).

The chapter has focused on knowledge selection and organisation, and the ideologies and intentions underlying these processes. We are aware that the intended curriculum is only a foundation from which teachers’ and learners’ own knowledge construction emerges. This emergence is influenced by sets of ‘conditions that enable and constrain learning’ (Brown 2009: 5). The power of such conditions in influencing learning is illustrated, for example, in Chapter 5 in which Gavin Heath and Rob O’Donoghue explore the use of theory of practice architectures as a tool for investigating how cultural-discursive, material-economic and social-political architectures (Kemmis et al. 2014) influence the emergence of student teachers’ knowledge of water catchment management in the teaching of Geography. Additionally the impact of context on teacher learning is a focus in Section D of this book.

This chapter positions the other five chapters that have been selected for this section of the book on environment and sustainability knowledge. In addition, it serves

as a foundation for Section B of this book in which the pedagogical implications of the described characteristics of environment and sustainability knowledge are explored. For example, the threads of situated, values-based and transformative knowledge are also explored in Section B from the perspective of teaching and learning. Section C picks up the threads of discipline-based knowledge and transformative intent in ESD. Finally, these three sections are pulled together in Section D which offers teacher professional development perspectives from the Fundisa for Change research programme.

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Chapter 2

Strengthening Environment and Sustainability Subject Knowledge

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