CHAPTER 3

Investigating the Nature of Biodiversity Knowledge in Natural Sciences Curriculum and Textbooks

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Background and context

In 1992, the international Convention on Biological Diversity (CBD) emphasised biodiversity as a measure for sustainability and recognised communication, education and public awareness as important for the successful implementation of the Convention's aims (CBD 1992). In 2002, the United Nations Decade of Education for Sustainable Development (2005–2014) included biodiversity as one of its key priorities (Unesco 2005). Later, Unesco's (2014) Global Action Plan on Education for Sustainable Development highlighted biodiversity as 'critical content', to be included in national curricula for holistic and transformational education.

In 2015, the United Nations included a concern for biodiversity in the Sustainable Development Goals, making a commitment that:

We recognise that social and economic development depends on the sustainable management of our planet's natural resources. We are therefore determined to conserve and sustainably use oceans and seas, freshwater resources, as well as forests, mountains and dry lands and to protect biodiversity, ecosystems and wildlife. (United Nations 2015: 13)

In reporting on these goals at an international level, the United Nations (2019) notes small successes in the 'Life on Land' goal with declining rates of forest loss (note: not declining *loss*, but declining *rates* of loss) and some innovative conservation strategies. However, in general, species extinction continues at an alarming rate (in fact, it is accelerating); coverage of protected spaces in key biodiversity areas is increasing, but insufficiently to meet targets and at a decreasing rate; and land degradation continues to increase while affecting the lives of one billion people. The 'Life below Water' goal has some positive achievements in conservation and management of marine resources and the possibility for improved management of land-based pollutants and marine debris. However, ocean acidification – named as 'the silent killer' or 'global warming's evil twin' (Bach et al. 2017) – is accelerating with an estimated increase (at the current rate of carbon emission) of between 100 and 150% by the end of the century (United Nations 2019).

The crisis of biodiversity loss described above indicates that understanding fauna, flora and their habitats is insufficient to understanding human impact and to support agency for social-ecological change. A more transformative response to human interactions with biodiversity is implied in the latest Convention on Biological Diversity's Aichi Target 19, which states that by 2020 knowledge, the science base and technologies relating to biodiversity, its values, functioning, status, trends and the consequences of its loss, need to be improved, widely shared, transferred and applied (Dhandapani et al. 2019). Education is seen and acknowledged as an important tool to achieve sustainability as well as biodiversity protection through the transformation of human attitudes towards nature (Ehrlich & Pringle 2008).

At a national level, South Africa contains extraordinarily high levels of biodiversity, in terms of species richness and local endemism (Siegfried 1989). Hence, South Africa has an important position and a practical role to play in the protection of global biodiversity. South Africa, like other developing countries, experiences a conflict between biodiversity conservation and economic development. Over 12 million South Africans depend on the natural environment to meet their needs (Driver et al. 2012). This results in overharvesting of biological resources as one of the main causes of biodiversity loss in the country (South Africa DEA 2014). The State of South Africa's Biodiversity 2012 report warns that if Gauteng, KwaZulu-Natal and North West Province keep losing natural landscapes at the current rate; to cultivation, mining, urban expansion and other causes; these provinces will have almost no natural habitat left outside protected areas by 2050 (SANBI 2013).

South Africa is party to international biodiversity conservation initiatives and has national policies aimed at conserving biodiversity such as the National Environmental Management Biodiversity Act. This Act provides for the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act 10 of 2004.

From a national educational perspective, as reported in Chapter 2 (Schudel and Lotz-Sisitka), 'environment' was a phase organiser in the post-apartheid Curriculum 2005 (Chisholm 2005). This enabled integration of topics such as biodiversity into different learning areas through this cross-curriculum approach to curriculum design.

In the Revised National Curriculum Statement (RNCS), the Senior Phase (Grades 7, 8 and 9) included biodiversity constructs under the 'Life and Living' strand, which stated that: 'Life and Living focuses on life processes and healthy living, for understanding balance and change in environments, and on the importance of biodiversity' (South Africa DoE 2002).

The 2012 CAPS inherited the interest in environmental concerns and included environmental knowledge content (see Chapter 2). Specific environmental content knowledge such as pollution, climate change and biodiversity is incorporated in various subjects including Natural Sciences. In the Grade 7 Natural Sciences CAPS, biodiversity is presented as a concept to be explored through topics presented in the first term. Biodiversity includes: 'plants, animals and microorganisms, and their habitats [that] make up the total biodiversity of the Earth'. Grade 8 has topics that address biodiversity, specifically interactions and interdependence in ecosystems. Grade 9 outlines topics related to biodiversity in Term 4 in the 'Planet Earth and Beyond' knowledge strand, with sub-topics such as the greenhouse effect (South Africa DBE 2011).

As can be seen, South Africa includes this important topic in its curriculum to some extent. However, very little has been achieved with regard to ensuring that environmental issues such as loss of biodiversity are consistently and coherently implemented in the school curriculum (Lotz-Sisitka 2011). Kadji-Beltran (2002) acknowledges that, as with any new topic, project, or programme, the implementation of biodiversity in the educational system depends on a number of factors. These might include how the curriculum structures content knowledge for biodiversity initiatives. Part of this chapter's purpose is to narrate the scope, depth, progression, valuing and contextualisation of biodiversity content knowledge with regard to continuity and discontinuities as it is recontextualised across these curriculum spaces.

The study on which this chapter reflects is framed by the following research question:

What is the nature of biodiversity knowledge presented in the Senior Phase Natural Sciences curriculum and selected textbooks in relation to international and national scientific documents?

Theoretical tools of the study

The Pedagogic Device is an attempt to describe the general principles which are central to the transformation of knowledge; namely the principles of distribution, recontextualisation and evaluation (Bernstein 1996). The Pedagogic Device is made up of a number of fields in which these principles play out (Bernstein 1990).

Important for this paper was the specific principle of recontextualisation. This principle helps with understanding how knowledge is recontextualised as content is developed from the scientific field in which it is generated and reproduced in the pedagogic discourse of the curriculum and textbooks supporting curriculum implementation. Bernstein describes firstly the Field of Production (FOP), where new knowledge is constructed

and compiled by scientists. It is then recontextualised (delocated and then selectively appropriated or transformed as it is relocated) through Official Pedagogic Discourse (OPD) in two recontextualising fields. The first of these is the Official Recontextualising Field (ORF) which is created by the official recontextualisers (curriculum developers). Further recontextualisation occurs in the Pedagogic Recontextualising Field (PRF) when knowledge is recontextualised by textbook writers and teacher educators (Bernstein 1990). The Field of Reproduction (FOR) is where recontextualised discourses are transformed a second time for general consumption, and where pedagogy and curriculum are actually enacted in schools (Apple 2003). Of interest for this chapter was the content of biodiversity knowledge presented in the Natural Sciences curriculum and how this related to the commonly used Grade 7–9 Natural Sciences textbooks. The study focuses only on the ORF and PRF, and further insights into biodiversity knowledge in the FOR can be read in Chapter 4 by Isaacs and Olvitt.

Methodology

This study was a social realist investigation that shifts the focus from ‘whose’ knowledge to an emphasis on ‘what’ knowledge (Lilliedahl 2015). It also shifts from viewing knowledge in terms of its construction to its production, within the relatively independent scientific fields (Young 2008). According to Maton and Moore (2010), knowledge is the very basis of education as a social field of practice. It is the production, recontextualisation, teaching and learning of knowledge that makes education a distinct field (p.2). The study also has a social realist interest in placing knowledge as an object at the centre of thinking about education.

Document review was used as the main method for this study. The Millennium Ecosystem Assessment (MEA 2005) and Life: The State of South Africa’s Biodiversity 2012 (SANBI 2013) were used to identify the scope and depth of biodiversity knowledge in the FOP. The CAPS policy document and three Grade 7–9 textbooks (one per grade across Grades 7, 8 and 9) were also used to look at how the identified biodiversity knowledge had been recontextualised. The South African national curriculum catalogue allows for a maximum of seven textbooks per subject. However, the textbooks have not been specifically identified as the purpose of the study was not to evaluate the textbooks per se, but to highlight the process of recontextualisation from curriculum to textbook and to sensitise future textbook writers to specific aspects of biodiversity content knowledge. For data tracing, the policy documents were labelled CAPS 7, 8 and 9 respectively and the textbooks were labelled T7, T8 and T9.

The study relied on content analysis of documents as its analytic technique. Downe-Wambolt (1992) defined content analysis as a research method that provides a systematic and objective means to make valid inferences from verbal, visual or written data in order to describe specific phenomena. Content analysis can be used on all types of written texts no matter where the material comes from (Berg 2001; Burnard 1991; Catanzaro 1988). According to Cohen, Manion and Morrison (2007), content analysis takes texts and reduces and interrogates these through categories and emergent themes.

For analysis, the study required an understanding of what is meant by ‘biodiversity’. The study used Lévêque’s (1997) representation of biodiversity at three different levels: species diversity, genetic diversity and ecosystem diversity. To explore the possible scope and depth of biodiversity knowledge in the scientific community, the first phase of analysis in the study identified biodiversity themes that emerged from an inductive analysis of the Millennium Ecosystem Assessment (MEA 2005), and a South African biodiversity document, *Life: The State of South Africa’s Biodiversity 2012* (SANBI 2013). The following features of biodiversity knowledge emerged from the analysis of these documents: ecosystem services, biodiversity loss (including threats to and extent of biodiversity loss), conservation and restoration.

Having outlined these themes, the study included a further internal analysis of the curriculum and Grades 7–9 textbooks. To do this we drew on Bernstein’s notion of horizontal and vertical discourse to construct an analytic frame for reviewing the **scope, depth, progression, valuing and contextualisation** of biodiversity knowledge. According to Bernstein (2000) the structure of knowledge is just as important as the content of knowledge. Thus, the first three analytic categories were the **scope** and **depth** of the content, and the **progression** of that knowledge from grade to grade. Progression is critical in South African curriculum design due to historical concerns with previous curricula which experienced ‘compromised conceptual learning and progression within subjects’ (Dada et al. 2009: 24). The interest in scope and progression is consistent with Bernstein’s notion of ‘vertical discourse’, which describes that aspect of a curriculum where knowledge is ‘coherent, explicit, [with] systematically principled structure, hierarchically organised’ (1999: 159).

Also relevant was Bernstein’s (2000) notion of ‘horizontal discourse’ which he describes as ‘a set of strategies which are local, segmentally organised, context specific and dependent, for maximising encounters with persons and habitat’. Ellery (2016: 50) elaborates that horizontal knowledge structures ‘develop through competing claims that have an ideological base and are thus much more dependent upon *who* is making the knowledge claim, rather than on *what* is the claim’. Ideological considerations as well as ‘who’ questions regarding the context of knowledge development and the value of indigenous knowledge are evident in the Natural Sciences curriculum which requires an approach to learning that highlights:

- knowledge in local contexts, while being sensitive to global imperatives;
- the different cultural contexts in which indigenous knowledge systems have developed;
- the contribution of Science to social justice and societal development; and
- the need for using scientific knowledge responsibly in the interest of ourselves, society and the environment. (South Africa DBE 2011: 9)

The ideological interest in this study is captured in the analytic category of **valuing**, and the ‘whose knowledge’ interest by the analytic category of **contextualisation**.

Research findings

Biodiversity knowledge in international and national documents

The international Millennium Ecosystem Assessment (MEA) and the national SANBI scientific reports analysed for this study present knowledge that allows us to understand the value of biodiversity in the environment as well as how human beings interact with it. They present knowledge of the relationship between diversity and human well-being and the services we get from ecosystems. Among these services that give insight into the value of biodiversity are: supporting services (including soil formation and nutrient cycling); provisioning services (such as food, medicine, health and others); regulatory services (including climate and flood regulation); and cultural (including aesthetic, spiritual, and more) (MEA 2005). There is also coverage of how the loss of biodiversity may damage the Earth's ecological balance, thus disturbing cycles of rain and drought, seasonal temperatures and nutrient exchange. The concept of restoration is covered through cases of re-establishment of habitats, landscapes and biodiversity that have been altered or destroyed. The two documents also describe natural ecosystems in protected areas, national parks, biological reserves and other conservation sectors, thus highlighting the theme of 'conservation' in these documents as well. This analysis indicates that besides **defining biodiversity** and basic **ecological knowledge** (which we expected to find in the curriculum); increased depth of biodiversity knowledge available in the FOP includes **ecosystem services**, **threats to biodiversity** and **conservation and restoration**. These five themes became the themes used in narrating the content of the curriculum and textbook. This analysis is presented below.

Biodiversity knowledge in the CAPS and textbooks

Defining biodiversity

In the Natural Science Senior Phase, there is no explicit distinction between the three components (genetic diversity, species diversity and ecosystems diversity) of biodiversity. However, an important foundational concept for understanding genetic biodiversity is the topic of 'variation within species', which links to the notion of genetic biodiversity in Grade 7. The CAPS and the textbook define species as 'a category within the classification system'. The Grade 7 CAPS uses the concept of biodiversity without fully or explicitly defining it in its explanation that 'plants, animals and microorganisms, and their habitats make up the total biodiversity of the Earth'. The textbook expands on this foundational knowledge by explaining and giving examples of aquatic and desert biomes and how animals and plants need to be physically and behaviourally adapted to survive in these biomes. It illustrates this point through contextualising pictures, such as of the gemsbok, camelthorn tree and social weavers that live in the Kalahari Desert.

Neither the Grade 8 nor 9 CAPS elaborate on a definition of biodiversity. However, the Grade 8 CAPS introduces the notion of, and defines, ecosystems,

while the Grade 9 curriculum gives more detail on the notion of species under the topic of cells, explaining that: 'DNA is unique to each person; this variation accounts for differences within species'. Both the concepts of species and ecosystems are therefore introduced at the Senior Phase, but without employing them to define biodiversity specifically.

Ecological knowledge

The Grade 7 textbook extends this initial understanding of ecology and introduces the notion of vulnerability of species through the statement that 'survival of living organisms depends on ecosystems: access to water, air, food, space, favourable temperatures and protection from enemies'. However, ecosystems have still not yet been noted as a concept that Grade 7 learners should know.

In Grade 8, under the topic 'interactions and interdependence within the environment', the concept of ecology is introduced as the study of interactions of organisms with one another and with the physical and chemical environment. The CAPS lists four levels of ecological interactions: populations, communities, ecosystems and the biosphere. The textbook elaborates by defining each of these levels. The level of community is illustrated through a picture showing elephants and thorn trees as part of the community of the Kruger National Park.

In Grade 8, the sub-topic, 'feeding relationships', covers relationships between producers, consumers, herbivores, carnivores, scavengers, insectivores and decomposers. The CAPS and textbook extend this into knowledge about energy and nutrient flows. They follow this with ecological knowledge about food chains, food webs and trophic levels.

Ecosystem services

Examples of the notion of ecosystem services in Grade 7 are limited. One example is a 'did you know box' in the textbook, giving a contextualising example under 'living organisms'. This insert illustrates provisioning services, namely a description of how the seedpods of the camelthorn tree, *Erioloba acacia*, are made into a nutritious porridge and eaten by local people.

The Grade 7 CAPS also provides foundational knowledge for understanding regulatory services through the topic of 'pollination' under 'sexual reproduction'. An important human-environment relationship covered in this section is how pollinators play a key role in the production of food crops (such as maize) for humans. This example is a problematic one as maize is pollinated by wind, not pollinators such as insects, birds or mammals (the examples of pollinators given in the curriculum). The textbook explains pollination and adaptations by plants for pollination by wind and insects but does not highlight the human-environmental relations in terms of pollination of food crops which might have been elaborated using accurate examples such as beans, pumpkin or many other examples.

In the Grade 8 CAPS and textbook, relationships between humans and the environment are highlighted in the main topic, Interactions and Interdependence within the Environment – although humans are not necessarily always included in this notion of interdependence. The textbook only acknowledges humans within this interdependent system by including a number of examples that begin to illustrate ecosystem services:

- An explanation of how some micro-organisms are used by people for making certain foods (such as yoghurt) and medicines such as penicillin (provisioning services).
- Examples of indigenous plants which often contain ingredients that can be used for medicines (provisioning services).
- Discussion of how nature reserves give people great pleasure and are tourist attractions (cultural services).
- Description of the role of wetlands in filtering and cleaning water, controlling and reducing its flow (regulatory services).

The Grade 9 CAPS policy document did not continue with this focus on ecosystem services content.

Threats to biodiversity

The Grade 7 CAPS does not explicitly deal with threats to biodiversity, but without understanding the multitude of different types of living organisms on Earth and the notion of ‘variation’ (the foundational knowledge described above), learners might struggle to understand the significance of individual species and whole groups of organisms becoming extinct.

The textbook, however, implicitly opens up the notion of ‘threats’ and includes a section on how exotic plants can become alien invaders. This concept was broadened by a case study on ‘Humans and Aliens and how Port Jackson, *Acacia saligna*, was introduced to the Western Cape from Australia and it resulted in habitat loss’.

The Grade 8 curriculum has extensive coverage of threats to biodiversity, even if not explicitly labelled as such. The CAPS includes a focus on how organisms that are ‘unable to adapt to changes within the environment die out and become extinct’. The concept of extinction is broadened by the textbook, which explains that species that are less well adapted in the environment do not reproduce, disappear from the ecosystem and become extinct.

In the Grade 8 textbook, the energy flow sub-topic helps learners to evaluate the effect of removing an organism from a food web. This helps to underpin an understanding of biodiversity loss and to make judgements about the complex network of interactions in an ecosystem. For example, the question was posed: ‘What will happen to the population of rats and mice if they are not being preyed upon by hawks?’ Other questions were: ‘What could happen to the population of mongoose because of

the change in population size of the rats and mice? Could the loss of hawks affect the population of hadeda ibis? What other populations might be affected by the loss of the hawks in this food web?’

The Grade 8 CAPS includes a focus on understanding that an ecosystem can only accommodate as many organisms as its resources (food, water and shelter) can carry, and will fail if it does not remain in balance. According to CAPS, ‘adaptation is the change in the structural, functional and behavioural characteristics of an organism’. It states further that adaptation allows the organism to survive as it adapts to changing conditions within the environment. The textbook presents knowledge on how structural and behavioural features of animals and plants enable them to survive in their habitat. Under the topic of adaptation, the textbook used in this study elaborates on the concept of ‘indigenous’ and explains how indigenous animals are better suited for our environment, naming examples of South African fauna and flora that are of value to humans, such as bat-eared foxes that eat pests such as rats and white ants. These notions of balance and adaptation illustrate the vulnerability of ecosystems and thus are critical to a foundational understanding of threats to biodiversity.

The CAPS and textbook further mention knowledge that is foundational to understanding biodiversity loss: namely how natural factors, which include extreme changes in patterns of weather and climate such as floods, drought and extreme and sudden changes in temperature, can harm ecosystems. In Grade 8, the relationship between humans and environment is noted, and the CAPS describes humans as ‘interfering’ and provides examples of ‘litter ... pathways ... and cutting of firewood’. Furthermore, the textbook explains human factors that cause disruption of the world’s ecosystems. For example, people cause harm when they remove the animals and plants that were in balance with the ecosystem, through hunting, poaching, burning and cultivating land. Later in the textbook, acid rain is mentioned as a threat that destroys life in many rivers and damages plants.

The Grade 8 CAPS prescribes an assessment task where learners ‘evaluate disruptions to an ecosystem giving causes, effects and solutions’. The textbook gives an activity for learners to investigate examples of human interferences in their area. The concept of biodiversity threats is also broadened by discussions in the textbook using examples of research case studies that can be explored by learners. The first research study is about lack of food in a game reserve due to drought in Tsavo National Park, Kenya; the second covers habitat destruction due to farming; the third involves conversion of Brazilian rainforest into grass for cattle ranching and reduced migration due to fencing in game reserves; the fourth is about the need to cull elephants in Kruger National Park; the fifth considers the effect of hunting which brought about the extinction of the quagga in the Karoo; and the last is about mining, specifically the effect of titanium mining on coastal sand dunes.

Notably, all the biodiversity knowledge presented up to this point in the Senior Phase Natural Science curriculum falls under the knowledge strand of ‘Life and Living’, which forms the backbone of the Life Sciences subject in Further Education and Training. The examples that follow of mining and the greenhouse effect fit under the

‘Earth and Beyond’ knowledge strand, the backbone for Geography; and the example of waste and recycling falls under the knowledge strand ‘Matter and Materials’, the backbone of Chemistry. These strands and their link to biodiversity are now discussed in more detail.

The Grade 9 CAPS prescribes the topic of ‘threats’ caused by mining in South Africa. According to CAPS, there is large-scale mining activity in South Africa which causes significant environmental impacts such as creation of mine dumps, pollution of water resources, damage to places with high tourist or cultural heritage value, and loss of farming and wildlife habitat. While biodiversity loss is not explicitly discussed here, these environmental issues can be directly related to biodiversity loss. The textbook repeats the lists of environmental issues associated with mining.

The Grade 9 CAPS prescribes knowledge, supported by the textbook, of how ‘greenhouse gases trap ultraviolet radiation’, which then warms the air closest to the surface of the Earth like inside a greenhouse. However, this is a misconception and ignores the subtlety of the role of ultraviolet and infrared in global warming. The CAPS and textbook list the most common greenhouse gases as carbon dioxide, water vapour and methane, and mention that an increase in greenhouse gases leads to global warming. The textbook further adds that the greenhouse effect is a natural phenomenon and that it warms the atmosphere sufficiently to sustain life, going into a bit more detail than what is outlined in the CAPS.

Both the Grade 9 CAPS and the textbook present knowledge for understanding the effects of climate change on human health, photosynthesis, life cycles and population size of species. The textbook adds that global warming is a potentially life-threatening problem on Earth. Both CAPS and the textbook explain that global warming could lead to climate change, rising sea levels, food shortages and mass extinctions. Mass extinction is one aspect of biodiversity loss, but does not capture all the nuances and aspects of biodiversity loss.

Conservation and restoration

No discussion of conservation or restoration actions are prescribed in the Grade 7 CAPS or textbooks.

Under the topic ‘Conservation of ecosystems’ the Grade 8 CAPS includes knowledge for managing ecosystems and preservation of wetlands. For example, the policy prescribes knowledge that ‘environmentalists and others work towards managing ecosystems, such as control of alien vegetation’. The textbook includes a focus on how natural habitats that are conserved can generate money which can be used for the maintenance and development of protected areas. The textbook contextualises this by describing the Maloti/Drakensberg Transfrontier Conservation Area, which was established to protect the special ecosystems of the area and the water supply which originates there. This document also lists how individuals can contribute to conservation in various ways, such as through appropriate waste disposal that includes recycling and re-using.

The Grade 9 CAPS does not prescribe conservation and sustainability with respect to biodiversity. However, the textbook presents content about the Department of Minerals and Energy regulations regarding ecological health within the mining industry in South Africa. It includes knowledge on what can be done to slow global warming. It states that governments need to take drastic action to cut back the use of fossil fuels, although this is not easy because the economy depends on electrical power. It is in Grade 9 where the important foundational knowledge of the social-ecological complexity of sustainability is implicitly addressed.

Summary of findings and emerging recommendations

The chapter introduced its interest in the scope, depth, structure, nature and contextualisation of biodiversity knowledge. Table 1 below shows the **scope of concepts** under the five dimensions of biodiversity identified as relevant for a **depth understanding** of biodiversity. Each of these concepts is considered in terms of **progression** in the Senior Phase curriculum for Grades 7, 8 and 9. This makes it possible to see how one concept builds on the other. Finally, Table 1 gives examples of how the different concepts are **contextualised** by both the CAPS and the textbooks.

Table 1. Summary of Grade 7, 8 and 9 CAPS curriculum and textbook analysis

CONCEPTUAL DEPTH	CONCEPTUAL SCOPE	PROGRESSION			ILLUSTRATIVE EXAMPLES CAPS OR TEXTBOOK (TB)
		Grade			
		7	8	9	
Concepts used in Defining Biodiversity	Species	✓	✗	✗	
	Biome	✓	✗	✗	Aquatic & desert examples (Grade 7 TB)
	Ecosystem	✗	✓	✗	
	Variation within species	✓	✓	✓	
Further Ecological Concepts and Principles	Ecology and interaction	✗	✓	✗	
	Interdependence (populations, communities, ecosystems, biosphere)	✗	✓	✗	Elephants in Kruger Park (Grade 8 TB)
	Feeding relationships (food chains and webs)	✗	✓	✗	Bat-eared foxes, ants and rats (Grade 8 TB)
	Food pyramids and trophic levels	✗	✓	✗	
	Energy flows	✗	✓	✗	
	Nutrient flows	✗	✓	✗	

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CONCEPTUAL DEPTH	CONCEPTUAL SCOPE	PROGRESSION			ILLUSTRATIVE EXAMPLES CAPS OR TEXTBOOK (TB)
		Grade			
		7	8	9	
Ecosystem Services	Provisioning	½	½	✗	Camelthorn seeds used for human porridge (Grade 7 TB); micro-organisms for food and medicine & plants for medicine (Grade 8 TB)
	Cultural	✗	½	✗	Tourism (Grade 8 TB)
	Regulatory	½	½	✗	Pollination (Grade 7 TB); Wetlands for purifying water (Grade 8 TB)
Threats to Biodiversity	Survival and adaptation	✓	✓	✗	
	Habitat loss	✓	✗	✗	Port Jackson invasives causing habitat loss (Grade 7 TB)
	Species extinction	✗	✓	✗	
	Food web disruption	✗	✓	✗	Effects of removing populations from food web (Grade 8 TB)
	Natural threats	✗	✓	✗	
	Human threats: litter, cutting trees (CAPS); hunting, poaching, cultivating, acid rain (TB)	✗	✓	✗	TB cases: Drought in nature reserve, habitat destruction and farming, rainforest loss in Brazil, elephant culling, hunting quagga to extinction, mining & effect on dunes.
	Greenhouse effect (affects biodiversity)	✗	✗	✓	
	Mining of minerals (Environmental impact)	✗	✗	✓	
Conservation	Ecosystem management	✗	✓	✗	Maloti/Drakensberg Park (Grade 8 TB)
	Ecosystem conservation	✗	✓	✗	Wetland preservation (Grade 8 CAPS)
	Individual re-use and recycling	✗	✗	✓	
	Global warming mitigation	✗	✗	✓	
✓ present; ✗ absent; ½ present but only implicitly					

From Table 1 we can see that, regarding conceptual scope, key ecological concepts are introduced in Grade 7. These then form the foundation for understanding more complex relational interactions, as ecological concepts and principles are introduced in Grade 8. Grade 8 thus stands out as a particularly important grade for environmental learning, where the understanding of ecological principles offers an important foundation for forming arguments about human impact in Grade 11.

Also significant for understanding human impact in Grade 11 are the Grade 8 emphases on particular human activities that all have some impact on biodiversity (hunting, poaching, drought, farming, rainforest destruction and mining), and the addition of waste management and global warming in Grade 9. In Grade 9, these ecological principles form an important foundation for knowledge of ecosystem

conservation and management. Thus, there is a logical progression from grade to grade and an increase in depth of knowledge from basic understanding of ecological principles to understanding the consequences of disruption and how human agents can respond and impact positively through restoration and conservation.

In order for the full potential of the scope and depth of the curriculum to be met, however, the incremental progression from grade to grade is something that needs to be drawn to the attention of teachers. For teacher training, this highlights the criticality of implementing revisions from grade to grade and for teachers to be reminded that they should use the concepts taught in previous grades to help learners to build understanding and arguments. There are suggestions that perhaps this critical aspect of curriculum progression is not being implemented in classrooms as indicated. This is evidenced, for example, by the 2015 National Senior Certificate diagnostic report which suggests that ‘teachers might be neglecting to cover basic concepts effectively in the process of progressing to higher-order aspects of topics’ (South Africa DBE 2016: 6).

Another progression concern raised in this study is the problematic explanation of the greenhouse effect as described in the findings. Global warming is a concept that is becoming more and more integrated into different subjects in the higher grades, including the Life Sciences. This is an example of misleading information that could result in the kinds of confusion around global warming described by Lotz-Sisitka and Mandikonga in Chapter 6 and Chitsiga and Schudel in Chapter 9. Recommendations from this study are that curricula and textbooks need to be carefully read, as well as offer a more accurate representation of global warming, as evidenced in the following extract:

Energy from the sun enters the Earth System in the form of short-wave [ultraviolet] radiation ... Only about half of the radiation arrives at the Earth’s surface. Because the Earth is much colder than the sun, it radiates some of this absorbed energy back into the atmosphere in the form of long-wave [infrared] radiation. The atmosphere, which is made up of various gases including carbon dioxide and water vapour, selectively absorbs this longer wavelength radiation. These gases in turn re-radiate this energy back into the atmosphere and then back towards the Earth. (Vogel et al. 2013: 20)

Accuracy is not the only aspect of the curriculum affecting progression here, but also subject boundaries. The socio-ecological nature of environmental learning requires complex understandings that move across disciplinary boundaries. Natural Sciences includes topics conventionally seen within the Earth Sciences and climate change is one of these. In the Grade 7–9 CAPS the topic is within the knowledge strand ‘Earth and Beyond’ which evolves in higher grades into Geography. It is notable that, for learners of the Life Sciences higher grades who are not concurrently taking Geography, this brief introduction to climate change is their only engagement with the topic until the Grade 11 segment is introduced as part of a range of ‘human impact’ topics. Thus, an emerging recommendation is that continuity in the topic of climate change be explored

from a Life Sciences perspective, as the prevailing situation might also explain why this topic, when examined in the final year of schooling, is poorly achieved.

Table 1 also illustrates the important role of the textbook in contextualising the curriculum concepts. The CAPS curriculum rarely makes reference to case studies that contextualise biodiversity. Notably, the examples provided by textbooks appropriately span specific species, specific ecosystems, specific relationships and specific management areas. In one case, an example from beyond South Africa, in Kenya, is given. Another case uses an example from outside Africa, that is, the Brazilian rainforest. While there are obvious time limitations in the curriculum coverage, there may be room for suggesting other African case studies, and particularly comparative studies between South Africa and other countries. This would serve to celebrate not only the local biodiversity but also the extensive global biodiversity. For example, if wetlands are studied, it may be instructive to compare the South African Ramsar protected sites with other wetlands around the world that have similar status. The international document studied in the FOP for this research is an example of where curriculum and textbook developers could conduct research for ensuring a local, regional and international contextualisation of biodiversity studies.

This leads to reflections on the ideologies inherent in biodiversity knowledge. For example, while the textbook makes implicit deference to South African biodiversity, the CAPS makes no explicit reference to the importance of recognising biodiversity that is indigenous to South Africa. The notion of 'alien' vegetation is introduced, however. This seems an illogical omission in the CAPS curriculum as one would need to know what the concept 'indigenous' means before one can understand what is 'alien' in relation to this. Therefore, a further recommendation from this study is for the progression of the concept of 'indigenous' to be carefully tracked in the next curriculum revision.

A second aspect of the ideologies inherent in the biodiversity knowledge presented in the CAPS and textbooks is how humans are presented as 'interfering' (which might have similarities to the survivalism discourse discussed by Isaacs and Olvitt in Chapter 4). This is problematic for two reasons: first, seeing humans as 'interfering' problematises human engagement in their environment, rather than highlighting a more positive human role in sustainability practices. Sustainability practices could bring a crucial changed perspective to the 'conservation and restoration' focus of Grade 9, and also to relationships between people and environment in the earlier grades.

Second, it is problematic because 'interference' implies the separation of humans from nature – a long-disputed perspective in the environmental field; whereas the focus should rather be one that is 'committed to achieving sustainable development in its three dimensions – economic, social and environmental – in a balanced and integrated manner' (United Nations 2015: 6). The international and national documents studied for this research as representative of the FOP for biodiversity knowledge illustrate how ecosystems provide the conditions for a healthy environment in which humans are accepted and able to draw on its resources (MEA 2005; SANBI 2013). This is where the second fundamental difference between the FOP, ORF and PRF in the pedagogic device becomes clear.

Conclusion

This chapter has conducted a detailed analysis of biodiversity knowledge in a specific curriculum and supporting textbooks. To do so, it has illustrated a methodology for document analysis that includes a focus on recontextualisation across the pedagogic device as combined with an internal analysis of the scope, depth, progression, valuing and contextualisation of curriculum concepts within the ORF and PRF.

Using this analysis strategy, it has made recommendations for curriculum and textbook revision in South Africa regarding checking for progression of the concept of ‘indigenous’, and for accuracies and continuity (especially around climate change knowledge). It has made suggestions for ensuring a balance of local, regional and international coverage of contextualising case studies and suggested that the perspective of humans as ‘interfering in nature’ ought to be reviewed and reconsidered. These latter two reviews could be achieved by drawing on key documents in the FOP. We suggest that this kind of coherence across the pedagogic device is critical if the logical structure of the parent discipline is to be made visible to learners (Abrie 2016).

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