CHAPTER 6

Making Sense of Climate Change in a National Curriculum

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Introduction

This chapter draws on three recent South African reviews of climate change education that have been undertaken by the authors: one in partnership with the United Nations Educational, Scientific and Cultural Organization (Unesco) and the South African National Biodiversity Institute (SANBI) in 2016 which produced a national case study on Climate Change Education in South Africa (Lotz-Sisitka & Mandikonza 2016); another that was undertaken for the Department of Environmental Affairs in 2018 for the Third National Communication on Climate Change for the United Nations Framework Convention for Climate Change (Lotz-Sisitka et al. 2018);¹ and a more recent review undertaken in the context of a research seminar series hosted by Rhodes University focusing on climate change education in South Africa (Lotz-Sisitka 2021). The chapter also draws on perspectives being developed in the Fundisa for Change Keep it Cool Project (VVOB/GreenMatter 2021) and from wider studies being undertaken for the international Monitoring and Evaluation of Climate Change Education programme (McKenzie 2020) and the International Science Council's Transgressive

¹ Part of this study was published in the South African Third National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) (Chapter 5, RSA 2019). Here we draw on the wider data set in addition to the published work in the South African TNC report to the UNFCCC (RSA DEA 2019).

Learning in Times of Climate Change research programme (Macintyre et al. 2018).² Drawing on these reviews which are both conceptual and empirical in nature, the chapter raises key issues around how we ‘make sense of’ dealing with climate change in a national curriculum context, with implications for curriculum development and teacher education praxis.

South Africa is located on the southernmost part of the African continent with a landmass of approximately 1 221 000 km² and is bordered by the Atlantic Ocean on its west coast and the southern Indian Ocean on its south and east coasts (RSA 2011a). It has a coastline of more than 2 500 km, a semi-arid and warm climate with strong gradients in both temperature and rainfall leading to a wide variety of regional and local climatic conditions. South Africa is a water-scarce country and it has been classified as highly vulnerable to water supply limitations (RSA 2011a).

The economic history of the country is built primarily on its mineral wealth and primary sectors such as agriculture, and one of the issues pertinent to climate change education, is the fact that South Africa’s economy is heavily dependent on coal and energy supply, is carbon-intensive, and currently insecure. Also pertinent to climate change education is the broader context of post-apartheid transformation, which the country has been pursuing since 1994 in which issues such as poverty, unemployment, poor quality and unequal education and training systems, and associated social ills are the focus of most policy initiatives. Progress has been made, but significant development challenges remain. Patterns of the past continue, especially when it comes to inequalities, which foregrounds a need for including a social justice perspective in climate change education. Despite the fact that there are more economically active people, and more historically disadvantaged people are now benefitting from the economy, high social inequalities persist. The Gini coefficient is between 0.66 and 0.69, still one of the highest in the world, a situation that has been exacerbated by the COVID-19 pandemic.

Climate change is already a measurable reality in South Africa, and along with other developing countries, South Africa is especially vulnerable to its impacts. Predicted impacts of climate change for South Africa include, among others, increases in the distribution and intensity of drought; reduced agricultural crop yields impacting on food security; potential species extinction; increased growth rates of invasive species; potentially catastrophic coral bleaching; and an increase in the areas affected by vector-borne diseases. It is also clearly stated in the South African Second National Communication to the UNFCCC (RSA 2011b) that, in all of these circumstances, it is the poor who would be worst affected. Specifically, projected impacts include:³

- **Water shortages:** South Africa is a water scarce country with a highly variable climate and has one of the lowest run-offs in the world. Official

2 The authors of this chapter are contributing to these programmes.

3 Information here is taken from the National Climate Change Response Strategy (RSA 2011a), and the Third National Communication submitted by the government to the UNFCCC (RSA 2018). This is just a brief summary of much more detailed information.

estimates suggest that South Africa will face shortages of between 2 and 13% of total water requirements by 2025. Other estimates that include climate change projections and other uncertainties calculate that these could increase to as much as 19–33% by 2025, and that South Africa will exceed limits of economically viable land-based water resources by 2050.

- **Agriculture and commercial forestry:** Climate change significantly impacts agriculture and commercial forestry. Agriculture is the largest consumer of water (through irrigation) and is vulnerable to changes in water availability, increased water pollution and soil erosion. Under-resourced, small-scale and subsistence farmers are particularly vulnerable to the impacts of climate change. Commercial forestry in the form of alien plantations reduces streamflow and so impacts on scarce water resources. It also reduces biodiversity.
- **Health and well-being:** There are several emerging and potential links between climate change and human health, particularly related to water scarcity and water quality as well as the geographical spread of vector and water-borne diseases, reduced air quality, and heat stress.
- **Biodiversity and ecosystems:** Climate change will compound the pressures on already stressed ecosystems that have resulted from the unsustainable use and inadequate management of many of South Africa's ecosystems, thus potentially reducing the quantity and quality of the services that ecosystems currently provide. These critical services underpin South Africa's socio-economic activities. Roughly 30% of endemic terrestrial species in South Africa may be at increasingly high risk of extinction by the latter half of this century if climate change is not mitigated.
- **Coastal areas:** Vulnerabilities of coastal areas have been identified as increased storm damage; damage to coastal infrastructure (including infrastructure such as breakwaters); threats to the erosion levels of shorelines; and changes in the salinity levels of estuaries, which will affect breeding grounds of many marine species. A significant proportion of South Africa's metropolitan areas, as well as numerous towns and smaller settlements, are situated along the coast, making them vulnerable to any dramatic sea-level rises.
- **Human Settlements (Urban, Rural, Coastal):** More than 60% of South Africa's population lives in urban areas. Urban areas are vulnerable to environmental health risks, and have a number of climate related challenges. Rural settlements in South Africa are characterised by inequalities and high levels of poverty, especially in former 'homeland' areas. This is also where most small-scale and homestead food production is practised, with roughly 1.3 million small-scale farm units, which are also home to 70% of the country's

poorest households. They too face several climate change challenges, especially increased vulnerability. Coastal settlements are also vulnerable to climate change, as they are at risk from sea-level rise. Coastal areas are home to about 40% of South Africans. The coast is generally exposed to moderate to strong wave action, with the coastline becoming increasingly vulnerable to storm surges, coastal erosion, sea-level rise and extreme weather events.

- **Energy and Greenhouse Gas emissions:** South Africa is a relatively significant contributor to global climate change with significant GHG emission levels from its energy-intensive, fossil-fuel-powered economy. South Africa therefore has significant mitigation challenges, in addition to adaptation challenges.
- **Temperature rise and general impacts:** Even under emission scenarios that are more conservative than current international emission trends, it has been predicted that by mid-century the South African coast will warm by around 1 to 2°C and the interior by around 2 to 3°C. By 2100, warming is projected to reach around 3 to 4°C along the coast, and 6 to 7°C in the interior. With such temperature increases, life as we know it will change radically: parts of the country will be much drier and increased evaporation will ensure an overall decrease in water availability. This will significantly affect human health, agriculture, and other water-intensive economic sectors such as the mining and electricity-generation sectors as well as the environment in general. Increased occurrence and severity of veld and forest fires, extreme weather events, and floods and droughts will also have significant impacts. Sea-level rise will impact the coast and coastal infrastructure. Mass extinctions of endemic plant and animal species will greatly reduce South Africa's biodiversity with consequent impacts on eco-system services (RSA 2011a).

The National Climate Change Response White Paper: Education implications and objectives

In 2011 the South African government released a National Climate Change Response White Paper (RSA 2011a). In terms of **adaptation**, the National Climate Change response includes a risk-based process to identify and prioritise short- and medium-term adaptation interventions to be addressed in sector plans (RSA DEA 2019). The National Climate Change Adaptation Strategy (RSA DEA 2019) outlines objectives for building climate resilience and adaptation capacity, promotion of climate change adaptation responses into development objectives, policy, planning and implementation, and ensuring that resources and systems are in place to enable implementation of climate change responses. Objective 3 is particularly significant for climate change education as it points to the need to 'Improve understanding of climate change impacts and capacity to respond to these impacts'. Sectors identified as being in need

of immediate attention are water, agriculture and forestry, health, biodiversity, and human settlements. The NCCR White Paper (RSA 2011a) also notes that resilience to climate variability and climate change related extreme weather events will be the basis for South Africa's future approach to disaster management and region-wide approaches will be used where appropriate. South Africa's approach to **mitigation** articulates the country's contribution to the international effort to curb global emissions (RSA 2011a).

The NCCR White Paper for South Africa (RSA 2011a) identifies priorities for adaptation and mitigation as follows:

ADAPTATION	MITIGATION
Main thematic areas: <ul style="list-style-type: none"> • Water • Agriculture and Commercial Forestry • Health • Biodiversity and Ecosystems • Human Settlements (Urban, Rural, Coastal) • Disaster Risk Reduction and Management 	Main thematic areas: <ul style="list-style-type: none"> • Benchmark National GHG Emissions • Carbon Budget approach • Sectoral mitigation • Lower carbon development strategies • GHG Emissions Inventory
CROSS-CUTTING ISSUES	
<ul style="list-style-type: none"> • Job creation • Mainstreaming climate resilient development (including into education and training systems) • Resource mobilisation • Monitoring and evaluation 	

The NCCR White Paper (RSA 2011a) was informed by the development of long-term Mitigation and Adaptation Scenarios which provide a longer-term view on climate change adaptation and mitigation. These set out the longer-term strategic direction for climate change response, and also point to particular education and training systems demands. From a mitigation point of view, there is a need to develop education and training programmes that orient South Africans to carbon budgeting, environmental design and engineering, low carbon technologies, energy efficiency, ecological economics, and sustainable production and consumption (RSA 2018). From an adaptation point of view there is a need to develop education that builds capacity for ecological infrastructure management, rehabilitation and stewardship, adaptive capacity, risk reduction and management, early warning and vulnerability reduction, climate change governance, and health and well-being promotion. Sustainable agriculture, resilience-building and vulnerability reduction are key approaches to develop in agricultural education, while ecosystem-based approaches and restoration of ecological integrity, along with stewardship, are some of the approaches to reducing biodiversity risk (RSA 2018). Mainstreaming climate change into secondary and tertiary education curricula is also identified as a key action in the National Climate Change Adaptation Strategy (RSA DEA 2019).

Besides these specific implications for climate change education that are embedded in the actual thematic areas for climate change adaptation and mitigation, the South African Climate Change Response Strategy (RSA 2011a, Section 11.2) **includes**

a strategic goal of improving climate change education in South Africa. It states that *‘Climate change is a relatively new issue that has cross-disciplinary and cross-sectoral implications in South Africa. Understanding the concept as well as the options to mitigate it and adapt to it is fundamental to future development pathways and the wellbeing of South African society.’* In this chapter we point to ‘different understandings’ of the concept that are circulating in the South African curriculum context, and propose a ‘way forward’ to strengthen alignment of the diversity of conceptual frameworks shaping both climate change education, and national policy.

The South African Climate Change Response White Paper Strategy (RSA 2011a) further suggests that to address the educational aspects of climate change *‘systematic interventions’* are required to empower and capacitate people. The South African government states:

*We need to mainstream climate change knowledge into education and training curricula. **Climate change education should be part of the broader framework of education for sustainable development**, and should equip South African citizens to re-orient society towards social, economic and ecological sustainability.* (RSA 2011a: 44)

This chapter considers how this is/or is not being done, and what might be done to strengthen further development and implementation of climate change education in a South African context.

While these policy commitments exist for climate change education, the Third National Communication to the UNFCCC indicates that South Africa lacks a *systemic* approach to climate change education, and that approaches to climate change education are fragmented and lack conceptual coherence (RSA 2018). The implementation of Climate Change Education (CCE) currently tends to be left to the willing and able. There is acknowledgement that a strategic home and driver for CCE needs to be found and there are recommendations that strategic discussions need to happen at higher levels of government across different departments such as Department of Environment, Forestry and Fisheries, Department of Basic Education, Department of Higher Education and Training, Department of Agriculture and Land Affairs, and the Department of Public Works and Department of Water and Sanitation, among others (RSA 2018). Coherent and co-ordinated cross-sectoral response structures are needed that are inclusive of all government departments with a role to play in climate-compatible development. At this point, a question to be asked is when and how the education and training imperatives in the National Climate Change Response Strategy and the National Climate Change Adaptation Strategy will be internalised, assimilated and responded to by the educational policy-making community in ways that bring about wider policy synergy in the national development landscape, as projected and anticipated in the National Climate Response Strategy.

In this regard, it is instructive to note that the United Nations Development Programme and the United Nations Framework Convention on Climate Change

National Determined Commitment Outlook Report (UNDP & UNFCCC 2019) takes stock of global climate ambitions and highlights that ‘Climate action is inseparable from sustainable development’, making the point that:

Governments increasingly recognize that action to address climate change is inseparable from delivering the Sustainable Development Goals ... [climate change is] ... disrupting national economies and affecting lives, with a disproportionate impact on the poor, and prioritizing adaptation to climate is increasingly seen as critical for resilient sustainable development. (UNDP & UNFCCC 2019)

With this in mind, it is helpful also to link Climate Change Education in South Africa to the SDGs, especially SDG 13 on climate action, which has a target on climate change education and empowerment, and SDG 4 on quality education, which has a target on integrating education for sustainable development into education and training systems as a key feature of quality education. These discourses, outlined above from the South African National Climate Change Response White Paper (RSA 2011a) the long-term mitigation scenarios, and the National Climate Change Adaptation Strategy (RSA DEA 2019), which have gone through important consultation processes, highlight a strong link between climate change literacy and climate science principles, as well as discourses of adaptation, mitigation, resilience, vulnerability reduction and sustainable development. These need to be considered in their full scope and implications (i.e. one cannot consider adaptation discourse without considering implications for sustainable agriculture) when integrating climate change into the schooling sector in South Africa.

An understanding of both climate science and earth systems (i.e. foundational concepts and knowledge), as well as action-orientated responses to climate change (adaptation, mitigation, resilience building, vulnerability reduction, sustainable practices, etc.) need to be included in a coherent manner within and across a national curriculum that seeks to address climate change. As indicated in the Fundisa for Change programme and across the chapters of this book, curriculum innovation is not just about knowledge, however; it is also about pedagogy and transformative learning, values and ethics and the promotion of environmental health and well-being, social justice for current and future generations, as well as a new ethic of care and relational foundation for human-environment interactions in the world.

Climate change knowledge in the national curriculum

The section above has considered the policy context and some of the discourses emerging from climate change policy in South Africa. We now consider the Curriculum and Assessment Policy Statement (CAPS) (RSA DBE 2011c) and how it approaches climate change (or not). The CAPS curriculum, building on earlier versions of the curriculum (see Schudel, Lotz-Sisitka, Songqwaru and Tshiningayamwe, Chapter 1) emphasises the need for ‘knowledge and skills that are meaningful to learners’ lives’ by including

both local and global contexts (see also Schudel and Lotz-Sisitka, Chapter 2). The knowledge, skills and values component should enable the learners to fully participate in their society. Issues of inclusivity, human rights, environmental and social justice are key drivers of curriculum structure and processes, as has been indicated elsewhere in this publication (see Schudel and Lotz-Sisitka, Chapter 2). Problem solving, critical thinking and creativity are some of the goals of the education agenda. The South African CAPS (Grade R–12) is based on the following principles:

- *Active and critical learning*: encouraging an active and critical approach to learning, rather than that of rote and uncritical learning of given truths.
- *High knowledge and high skills*: the minimum standards of knowledge and skills to be achieved at each grade are specified and set as high, achievable standards in all subjects.
- *Progression*: content and context of each grade shows progression from simple to complex.
- *Human rights, inclusivity, environmental and social justice*: infusing the principles and practices of social and environmental justice and human rights as defined in the Constitution of the Republic of South Africa. The CAPS curriculum is sensitive to issues of diversity, such as poverty, inequality, race, gender, language, age, disability and other factors.
- *Valuing indigenous knowledge systems*: acknowledging the rich history and heritage of this country as important contributors to nurturing the values contained in the Constitution.
- *Credibility and efficiency*: providing an education that is comparable in quality, breadth and depth to that of any other country.

While all of the above is valid, and although CAPS pays heed to these principles, they are yet to be fully realised, as can be seen from the analysis that follows. When it comes to climate change knowledge in the curriculum we find that most climate change related content, values, skills and competences development is found in the following CAPS subjects: Natural Sciences/Life Sciences, Life Skills/Life Orientation, Social Sciences, Geography and Agricultural Science, Agricultural Management Practices, and the Marine Sciences (a new subject).

Appendix A offers a brief summary of this subject content from the CAPS (RSA DBE 2011c) and demonstrates that in the Natural Sciences curriculum, climate and climate change related content is covered mainly in the ‘Planet Earth and Beyond’ strand. Climate and climate related concepts are covered under ‘Systems and Control’ in Technology. Therefore the main purpose is to produce learners who are knowledgeable of their environment and can innovate to live responsibly in it. Climate change education is also embedded within the ‘Environment Studies’ strand. The Further Education and Training (FET) Life Sciences curriculum seeks to develop awareness of what it means to be a responsible citizen in terms of environment and lifestyle choices

and deal with environmental impact, although climate change is not identified as a specific environmental impact.

The Life Skills and Life Orientation curriculum has content ranging from weather observations in Grade 1 to environmental rights and responsibilities and waste and pollution management. In the senior phases, the focus shifts to environmental health concerns and problem-solving skills in the context of community, local and global environmental concerns, of which climate change may be one (though not specified as such). There is some emphasis on disaster risk management, as well as personal views, lifestyles and the impacts of one's actions in life.

The Social Sciences and Geography curriculum carries content on renewable and non-renewable resources, water concerns and catchment management, climatology, and resources management. It also includes a focus on industrial development and sustainable industries, but this is generally poorly specified from a climate change impact perspective, and there are inconsistencies and contradictions in the way in which sustainable development, industrialisation and growth are represented in the curriculum. There is, however, some emphasis on development of a commitment to sustainable development, and it is only in Further Education and Training (FET) Geography that there is any in-depth study of climate science and climate related content, focusing on atmospheric dynamics such as the greenhouse effect, global warming and the impact of climate change on Africa's environment and people. Skills relate to weather monitoring and use of GIS technologies for climatology and meteorology, oceanography and Africa's weather and climate conditions, including issues such as droughts and desertification, regional risk and energy management. Thus, unless a learner specialises in FET Geography, they are not likely to engage in any significant depth with climate change foundational and applied knowledge (cf. Appendix A).

The Economic and Management Sciences curriculum contains inconsistencies and contradictions in poorly framed recommendations for green economy development that are in contradiction to the overriding narrative based on promotion of fossil-based industrial development, and the Agricultural curriculum likewise is characterised by similar contradictions.

The Agricultural Science Grade 10 curriculum has content on climate change and global warming, impacts of climate change and global warming on agriculture, short-term and long-term weather predictions and cyclic patterns of rainfall in South Africa, and agricultural adaptation measures to overcome climate change. However, there is no concept progression in Grades 11 and 12. While this content is included, it is also contradictory to other content in the curriculum that supports monocultural and high-demand irrigation technologies.

Coherence, progression and orientation

The curriculum seeks to address scientific as well as social justice related issues associated with environment and sustainability as this relates to the history of South

Africa, and to support learner empowerment, for example, via problem-solving approaches and environmental impact assessment studies. However, as can be seen from the above there are inconsistencies and a lack of clear progression in the way that climate change education is dealt with in the curriculum, with a bias towards cognitive forms of engagement with climate change issues and little emphasis on social learning and/or social-emotional engagements with climate change related concerns. This is a weakness identified more broadly by McKenzie (2020) in international approaches to climate change education. Unesco (2021) has also recently recommended integration of cognitive with socio-emotional and action-orientated (behavioural) education approaches in responding to SDG 13 on climate change action – an approach that overall is missing or absent from the South African CAPS curriculum when it comes to climate change education.

One of the issues associated with the ‘topic’ approach to including climate change in the CAPS curriculum is that it does not allow for approaches that reflect contemporary climate change sciences, which include approaches to science that (a) involve understanding of earth systems, (b) predictive sciences, and (c) inter- and transdisciplinary sciences that are transformation and action/response orientated. The South African curriculum deals in a patchy way with a above, but fails to deal adequately with b and c; thus it neglects both to prepare learners adequately with coherent foundational knowledge (provided by a and b), and with applied knowledge and capacity (provided by c).

As a result of this lack or absence, it is even more difficult to realise a social-ecological orientation to climate change education, which is the more mainstream orientation to climate sciences. This in turn affects possibilities for development of resilience-orientated approaches to climate change education. The main approach that teachers can use are approaches that integrate some ‘patchy’ aspects of climate change knowledge into specific subjects. There are also inconsistencies between the content being promoted in the curriculum and the national climate change adaptation, mitigation and resilience priorities outlined above, in other words, there is a mismatch between education-sector curriculum policy and national climate change response policy, with the result that, as noted above, some of the content is also contradictory within subjects.

This is not to suggest that the curriculum should only promote climate change policy content, but rather that it should provide a substantive foundation for engaging with national climate change priorities and policy directions. For example, it is interesting to note that climate change adaptation or mitigation is sporadically dealt with (see below) and that much of the other curriculum content is largely inconsistent with, or contradictory to, these orientations, and fails to develop a clear and systemic conceptual framework for a social-ecological systemic approach to dealing with climate change. It also fails to adopt a strong ‘transformative approach’ to dealing with climate change in South Africa, which is being argued for in the Global Change Social Sciences National Research Plan, for example (DSI/NRF 2020) and in the international literature on climate change education (e.g. Macintyre et al. 2019; McKenzie 2020; Unesco 2021).

Dealing with a patchwork approach to climate change education

From the brief analysis discussed above we can observe a somewhat ‘atomistic’ and ‘fragmented’ overall approach to climate change education in the South African curriculum context. This is due to the fact that different aspects of climate change education are to be found in sections of topics in different subjects of the Curriculum and Assessment Policy Grades R–12, as outlined above and shown in more detail in Appendix A. These ‘atomised’ sections or topics cover aspects of climate science, earth system science, climate change causes, impact on development, mitigation and adaptation – but without developing any clear, broad and/or holistic framework for interpreting these ‘fragments’ or atomistic aspects of climate change education. Mitigation, where it is present at all, focuses on the reduction of greenhouse gases. Teaching of climate and weather takes place in relation to adaptation of plants and wildlife. Other aspects such as climate, vegetation, human settlement lifestyles, and natural resources are all taught, but not related to each other; nor is climate change knowledge related to sustainable use of natural resources such as air and water or carbon footprint. Effects of climate on agriculture and food supply are mentioned, but this is not related to adaptation responses. The role of science and technology in food production is discussed but not in relation to climate change. Conservation or preservation and careful management of natural resources is mentioned in parts, but not related to diverse climatic regions, contexts or differences. The relationship between resources and economic development is mentioned but this is not linked to mitigation and concepts of low carbon future or climate-compatible development. The impact of overexploitation of resources on the environment and economy as well as issues of sustainable waste management are all found in the curriculum, but they lack a coherent related purpose and framework of understanding that can allow learners to ‘join the dots’ or make the links. The importance of developing systems thinking competence and other key competencies for sustainability is not developed.

Besides this atomistic and fragmented approach, there is no clear ‘progression pathway’ for such knowledge, and there is little guidance on how to develop agency for climate action as recommended by Unesco (2021). Issues such as climate risks and natural disasters, population growth, and diversity are explored at primary school level but it is not clear what the foundations of such knowledge is/should be, or how knowledge progression ‘builds’ over time in relation to concepts such as the relation between climate risks, natural disasters and/or population growth. The curriculum could be said to include a ‘basket of relevant topics’ but lacks a clear conceptual framework for adequate interpretation of such topics, and for the knowledge progression pathway that learners are to follow in growing their understanding of these ‘new topics’ and concepts that are found in the curriculum. This also has implications for how learners engage critically with the complexities and realities of climate science/climate change. There is, further, a need to ensure that the curriculum equips learners with a sense of agency – and urgency – to take action, and with the capabilities to develop responsiveness towards the real-life challenges of climate change, while also developing hope for the future (Unesco 2021).

It is not surprising therefore that the ‘basket of topics’ shows a somewhat confused mix of approaches to climate change education and/or education for sustainable development. Some topics reflect a socio-ecological risk approach through illustrating how issues are potentially hazardous to human existence, while others reflect sustainable development response approaches. Mitigation and adaptation are key, but topics that deal with these issues tend to reduce these important conceptual areas to the generation of greenhouse gases, and individualised action responses or fragmented aspects of the wider coherence of mitigation and adaptation responses. Tackling of development issues promotes a futures-orientated approach but does not develop a clear perspective on the meaning of climate-compatible development. Thus, while it seems that the curriculum has a lot of ‘scope’ and ‘interest’ in climate change education within an environment/education for sustainable development paradigm, there is a lot more that needs to be done to ensure curriculum coherence when it comes to the manner in which the issues are incorporated into the curriculum.

Conclusion: Moving forward

The current ‘status quo’ of environment/sustainability/climate change knowledge in the national curriculum would appear to require high-quality educational research that seeks to understand climate change knowledge production in the field of production; and a critical analysis of how this is being/should be recontextualised into official pedagogic discourse, into other fields of curriculum recontextualisation (i.e. teacher education and textbooks) and into the field of curriculum reproduction itself (i.e. at classroom level). A study by Nsubuga (2009) showed that without a clear conceptual framework for natural resource management education at national level (adequately derived from the field of knowledge production) poor-quality recontextualisation processes occurred in official pedagogic discourse (the curriculum); and in ongoing recontextualisations at teacher education, textbook, district level support, and at classroom practice level. As climate change knowledge is relatively new to most education systems, it includes many different facets (see also Schudel and Lotz-Sisitka, Chapter 2). Thus research into climate change education with the pedagogic device is vitally important to ensure a coherent approach to mainstreaming of climate change knowledge and its relationship to other forms of environment and sustainability knowledge.

Additionally, there is an urgency to work on appropriate support systems for teachers who ultimately need to have a wider perspective and understanding of these issues than is represented in the ‘fragmented’ topics of the curriculum, with many recommendations in this direction emerging from across the chapters of this book (see Schudel and Lotz-Sisitka, Chapter 2; Shumba, Mandikonza and Lotz-Sisitka, Chapter 12; Mkhabela and Schudel, Chapter 13).

In working towards a more coherent and foundational framework for climate change education in South Africa, we propose that scientific knowledge of earth systems and their risks and functioning, while necessary, is an inadequate framework for CCE on its own. Price (2021) has also noted that much of climate change

education is troubled by ‘slippages’ in discourse that fail to develop adequately clear understandings of climate change challenges and politics. We propose that in addition to strengthening the quality of climate science knowledge (and its certainties and uncertainties), there is need to give coherent attention to emergent multi-, inter- and transdisciplinary concepts such as risk, social-ecological systems change, adaptation and mitigation, as well as seasonal variability and societal transformations towards more sustainable futures within climate change education. Additionally, there is a need to develop pedagogical praxis for development of intergenerational understandings, values, learners’ agency for change, and reflexive co-learning competencies situated within proactive, socially just and transformative climate-compatible development orientation, without producing dualisms, contradictions or inconsistencies for learners in and through the curriculum. Also crucial is to foreground more strongly ethics and justice, action and agency, in addition to science and knowledge (see Figure 1 below) via transformative learning approaches that involve individual learners in classrooms, whole school environments and communities.

Figure 1. Adapted diagram offering a coherent framework for teaching climate change, and for conceptualising climate change education (adapted from Flynn, n.d. by Lotz-Sisitka 2021)

The ethical aspects need to be integral to both knowledge and pedagogy, and are at the heart of agency development, since motive drives agency; thus ethical praxis is central to self-directed and collective motive and agency development for responding to climate change and to the need for deep-seated transformations in society. As indicated in the curriculum principles, ethics are embedded, but not well grounded with regard to the way in which climate change education is currently being conceptualised in the South African CAPS curriculum. This clearly needs to be given more attention moving forward. There is also a need to consider the processes of ethics-led learning

(O'Donoghue et al. 2020) as expansive learning processes that draw on both foundational and systemic approaches to knowledge, and that develop transformative agency for change. Here pedagogical approaches that strengthen and develop active learning (see Section B of this book) and assessment processes that strengthen the assessment of ESD more holistically (see Shumba, Mandikonza and Lotz-Sisitka, Chapter 12; Mkhabela and Schudel, Chapter 13) are necessary. As pointed out above, the knowledge dimensions of climate change education are themselves complex and therefore require a more robust way of thinking about knowledge in the curriculum.

Ultimately, there is need to develop understanding(s) and pedagogical praxis for development of intergenerational understandings, values, learners' agency for change, and reflexive co-learning competences situated within proactive, socially just and transformative climate-compatible development orientation, without producing dualisms, contradictions or inconsistencies for learners. In a recent review, the lead author of this paper defined Climate Change Education as follows:

... an ethics-led transformative, transgressive social learning and agency process that builds regenerative cultures and activity for the future; informed by, but not limited to, science. Knowledge, Justice, Action should not be separated out in climate change education. This could form the foundation for how we approach CCE and then apply it to adaptation, mitigation, resilience building, disaster risk reduction and other areas of applied climate change responsiveness, and to different disciplines and inter-disciplinary contexts.
(Lotz-Sisitka 2021)

The above definition may offer a way forward or at the least a strong starting point for developing a more coherent framework for climate change education in South Africa that can respond to the problems identified in this chapter. Based on this review, and the works that the chapter is grounded in, it is clear that there is a need for a multi-stakeholder approach to conceptualising climate change education in the South African curriculum in a way that addresses the problems of inconsistency and 'patchiness'. The Department of Basic Education, who hold responsibility for curriculum development, should work with teacher educators, who are important mediators and recontextualisers in the higher education system, and with Fundisa for Change partners such as SANBI and the Department of Environmental Affairs, Forestry and Fisheries to better map out a meaningful foundational framework and progression pathway for climate change education in South Africa's curriculum. This needs to be done within and across the different curriculum areas within a whole systems approach that more adequately reflects the principles of the CAPS curriculum itself, and through this, provides better orientation in dealing with climate change education in teacher education settings.

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Appendix A (Tables based on the CAPS curriculum) (RSA DBE 2011c)

Science and Technology

Climate and climate change content: Natural Sciences and Technology (Grades 4–9)

Phase	Grade	Climate Science and Climate related content
Intermediate	4	'Planet Earth' covers content relevant for climate science knowledge. The Sun and Life.
	5	No visible evidence of climate science or climate change education
	6	Renewable ways to generate electricity is a concept under 'Mains Electricity'. 'Movement of the Earth and Planets' provides the scientific background useful for understanding Earth System Science.
Senior	7	The topics of the 'Biosphere covering atmospheric gases; Properties of materials; Heat energy; and Relationship of the sun to the earth' cover climate change science.
	8	'Earth as a system' and 'The Atmosphere' constitute climate science.
	9	Alternative sources of energy are covered under 'Energy and the national electricity grid'. Spheres of the Earth, including atmosphere; hydrosphere and lithosphere, are climate science concepts that are covered under the topic 'The Earth as a system'.

Climate and climate change content: Life Sciences FET (Grades 10–12)

Phase	Grade	Climate Science and Climate related content
FET	10	Strand 3 covers 'Biosphere and Ecosystems'. This topic enables learners to develop an understanding of constituents of the biosphere and how these components are connected into global systems. In this section the concept of environment is defined holistically. Energy and nutrient flow are discussed to the level of trophic levels. Nutrients cycles are developed here: water, carbon, oxygen and nitrogen. Changes in climate comprise a short section under 'History of Life on Earth', aimed particularly at explaining the Ice Ages. Impact of humans on biodiversity and the natural environment are discussed under fossil formation.
	11	Most of the climate change and climate related concepts are covered in this Grade and particularly in strand 3, 'Environment Studies: Human Impact on the Environment'. The atmosphere and climate change, including the greenhouse effect are covered in this section. Sub-topics of the section on 'Water' relate to climate change.
	12	Darwin's theory of evolution by Natural Selection is a climate change related concept.

Life Skills and Life Orientation

Climate and climate change content: Life Skills Curriculum (Grades R–3)

Phase	Grade	Climate Science and Climate related content
Foundational	R	Learners learn to notice the daily weather conditions, to describe the weather perceived and link weather patterns with the seasons of the year. Issues of a clean environment are introduced at this stage.
	1	Learners are taught to observe weather conditions and record observations using tools and symbols.
	2	What we need to live includes protection from the sun. The Seasons link clothes, food, plant and animal growth.
	3	Rights and responsibilities include the environment. Waste Management (re-use, recycle, reduce). Pollution and effects of pollution on the environment.

Climate and climate change content: Life Orientation Intermediate Phase (Grades 4–6)

Phase	Grade	Climate Science and Climate related content
Intermediate	4	concern for the environment – use of recyclable materials during design.
	5	concern for the environment – use of recyclable materials during design.
	6	concern for the environment – use of recyclable materials during design.

Climate and climate change content: Life Orientation (Grades 7–12)

Phase	Grade	Climate Science and Climate related content
Senior	7	Environmental Health is a sub-topic under Health, social and environmental responsibility but is limited to: – Community and individual projects and strategies to prevent and deal with environmental health problems. – Problem-solving skills: an action plan to address an environmental health problem and formulate environmentally sound choices and actions.
	8	Under Health, social and environmental responsibility , a section involving understanding of application of laws and policies to protect the health of the environment as well as honouring Earth Day.
	9	Under Health, social and environmental responsibility , the contributions of community-based and non-profit organisations to social and environmental health and sustainable development are dealt with.
FET	10	Under Health, social and environmental responsibility : Contemporary social and environmental issues that impact negatively on local and global communities are included – <i>even though climate change is not mentioned</i> . Under Social and Environmental Responsibility: Strategies to stop negative impact of contemporary social and environmental issues on local and global communities: knowledge and skills to take appropriate action are emphasised.

Chapter 6
Making Sense of Climate Change in a National Curriculum

Phase	Grade	Climate Science and Climate related content
FET	11	<p>Social and Environmental Responsibility: Environmental factors and disasters that cause ill-health, accidents, crises and disasters:</p> <ul style="list-style-type: none"> – Impact of environmental degradation on society and the Earth: soil erosion; air and water pollution; waste dumps; radiation; floods; fires; loss of open space/ lack of infrastructure. <p>Social and Environmental Responsibility: Climate change: causes, impact on development, mitigation and adaptation (<i>also covers Disaster Risk Reduction</i>).</p> <ul style="list-style-type: none"> – Community responsibility to provide environments and services that promote safe and healthy living. – Responsibilities of various levels of government: laws, regulations, rules and community services. – Educational and intervention programmes and impact studies. – Dealing with factors that cause ill-health on a personal level: attitudes, safety and first-aid skills and coping with disasters.
	12	<p>Social and Environmental Responsibility: A personal mission statement based on: Personal views, values, belief system, religion, ideologies, lifestyle (physical and emotional well-being), environmental responsibility, goals for studies and career choices.</p> <ul style="list-style-type: none"> – Impact of vision on: One's actions in life; one's immediate community; and society at large.

Social Sciences and Geography

Climate and climate change content: (Grades 7–9)

Grade	Climate Science and Climate related content
7	<p>Natural resources: Renewable and non-renewable resources; How resources are used and abused – includes water, soil, air, wildlife, fish; Concept of conservation; Reasons for conservation and the protection of resources.</p> <p>Water in South Africa: Water needs of people and the environment; Water supply and demand in South Africa; Concept of a catchment area; Role and management of catchment areas and rivers; Disappearing wetlands and why conservation is necessary – case study.</p>
8	<p>The Earth's revolution around the sun: Seasonal temperature changes; Seasonal changes in lengths of day and night; Seasonal temperature changes (among others).</p> <p>Climatology: Climate around the world including: Elements of climate – temperature, pressure, humidity, winds and precipitation; Kinds of climate: Tropical, subtropical, temperate, desert, semi-desert, continental, polar, Mediterranean, tundra and high mountain (alpine); links between climate regions and factors that influence temperature and rainfall.</p>
9	<p>Development issues:</p> <p>Resources and development: The impact of development on the world's natural resources; Sustainable use of resources for development.</p> <p>Industrial growth: The concept of industrial growth; The impact of industrial growth; Multinational corporations; Sustainable industries.</p> <p>Community development: Development as community participation; Positive community projects.</p>

Climate and climate change content: FET Geography (Grades 10–12)

Grade	Climate Science and Climate related content
10	<p>Field work for developing Geographical techniques necessary to understand weather information as well as to handle weather information: Using maps and other graphical representations: atlases, synoptic weather maps, temperature graphs; Collecting and recording data using a variety of techniques: using weather instruments, collecting weather information from the media; Processing, collating, interpreting and representing field work findings: line graphs, bar graphs, maps, diagrams and synoptic weather maps.</p> <p>The Atmosphere: Composition and Structure of the Atmosphere: troposphere, stratosphere, mesosphere and thermosphere; the ozone layer; causes and effects of ozone depletion; and ways to reduce ozone depletion.</p> <p>Heating of the Atmosphere including: processes associated with the heating of the atmosphere, the Greenhouse Effect – impact on people and the environment; global warming as well as the impact of climate and climate change on Africa’s environment and people – deserts, droughts, floods and rising sea levels.</p> <p>Moisture in the Atmosphere including: water in the atmosphere in different forms, such as water vapour and liquid; processes associated with evaporation, condensation and precipitation; the concepts of dew point, condensation level, humidity, relative humidity – factors affecting relative humidity.</p> <p>Reading and Interpreting Synoptic Weather Maps: weather elements: temperature, dew-point temperature, cloud cover, wind direction, wind speed and atmospheric pressure; weather conditions: rain, drizzle, thunderstorms, hail and snow, as illustrated on station models; and reading and interpreting a selection of synoptic weather maps.</p>
11	<p>Geographical Information Systems (GIS) including the application of GIS to climatology and meteorology, as well as oceanography, using satellite images.</p> <p>The Atmosphere with the following subtitles:</p> <p>The Earth’s Energy Balance: the unequal heating of the atmosphere – latitudinal and seasonal; significance of Earth’s axis and revolution around the Sun; and transfer of energy and energy balance – role of ocean currents and winds.</p> <p>Global Air Circulation: global air circulation and how it is related to world pressure belts; forms and causes of the different global air masses.</p> <p>Africa’s Weather and Climate: Africa’s climate regions; subsidence and convergence – link to rainfall; the role of oceans in climate control in Africa; El Niño and La Niña processes and their effects on Africa’s climate; and reading and interpreting synoptic weather maps.</p> <p>Droughts and Desertification: areas at risk: regional and local scales; causes of droughts; causes of desertification; effects of droughts and desertification on people and the environment, such as differences in vulnerability; management strategies – case studies.</p> <p>Resources and Sustainability relating to:</p> <p>Using Resources: development of the concept of sustainability in relation to resource use.</p> <p>Conventional Energy Sources and their Impact on the Environment: Forms of energy production in South Africa, their advantages and disadvantages as well as their impact in the long term.</p> <p>Non-conventional Energy Sources: the range of sources and how they are of growing importance, their effects and the South African Economy and the Environment.</p> <p>Energy Management in South Africa: South Africa’s changing energy needs; energy management, towards greener economies and sustainable lifestyles; responsibilities of governments, businesses.</p>

Chapter 6
Making Sense of Climate Change in a National Curriculum

Grade	Climate Science and Climate related content
12	<p>Mapping Techniques are revised including: the use of maps and other graphical representations: synoptic weather maps and temperature graphs.</p> <p>Climate and Weather: Mid-latitude Cyclones, their general characteristics and nature.</p> <p>Tropical Cyclones: their origin, nature and general characteristics. Impacts on human life and the environment.</p> <p>Subtropical Anticyclones and Associated Weather Conditions: nature of subtropical anticyclones, general characteristics and causes.</p> <p>Valley Climates: the nature of micro-climates and indicators.</p> <p>Urban Climates: urban and rural climate as micro-climates, pollution domes, their causes and effects.</p> <p>Agriculture: including factors that favour and hinder agriculture in South Africa, such as climate, soil, land ownership and trade.</p>