'Teaching and Learning for Climate Change' – the Role of Teacher Materials and Curriculum Design in South Africa

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Abstract

Climate change and variability are key challenges facing the planet and humanity, particularly in South Africa. The complexity of climate as an interconnected system, including earth and socio-ecological systems and 'deeper' thinking, requires critical enquiry as well as reflexive and transformative education approaches. This paper provides a synoptic overview of three emerging South African cases of teacher education materials development, high school material design, and the design and implementation of a new tertiary-degree offering centred on teaching and learning for climate change. A mixed-methods approach was used in all cases, with a central focus being climate change content knowledge and examples of teaching and curriculum design opportunities that can begin a 'transformative' learning journey for climate change action. Educators and facilitators, in most cases, noted that the approaches used enabled a more expansive understanding of climate change content knowledge, and, in some cases, although not tested in detail, seemed to also inspire action for climate change (deeper levels of learning). The paper is predicated on enabling improved understanding of climate change as a complex 'system' requiring a range of responses. Probing what may be required to begin a much 'deeper' understanding and appreciation of the implications of climate change both now and in the future, is also examined.

Introduction

Climate change can be described as one of a complex set of wicked challenges confronting humanity (Rittel & Webber, 1973). In this paper, we share some exploratory cases that help to highlight what may be required to bring about 'learning' for flexible and 'deep' thinking around climate change (e.g. Ohman, Ostman & Sandell, 2005; Leiserowitz, Kates & Parris, 2006; Sterling, 2001, 2004; Fazey, 2010; O'Brien *et al.*, 2013). There are very few exploratory, evidence-based curricula and materials-based research papers that document what it may take to live with and for climate change (e.g. Mutizwa & Pesanayi, 2014). By using three South African cases ranging across a learning spectrum from children in primary school, to adult learners in university, to trainers of trainers and teacher educators, we aim to close this gap.

In the paper, we explore how one can use learning materials and curriculum development efforts to enable comprehensive, critical learning in respect of climate change from a variety of perspectives. In addition to knowledge-based learning and materials design, this work also includes one of the first attempts in the country to include deeper-learning approaches that

focus on values and belief systems in climate change knowledge and experience which, some (e.g. Wals, 2010) argue, is a key challenge to improved systems understanding and integrative learning for change. We call for a move from simple content-based, silo approaches of addressing climate change education to a more systemic and 'deeper' enquiry that draws together biophysical, socio-economic and socio-psychological understandings.

The reasons for such a multifaceted, focused effort with respect to climate change is clear. Africa is one of the most vulnerable continents when it comes to climate change, based both on exposure to projected changes and low adaptive capacity (IPCC, 2007, 2014). The impacts of climate change and climate variability[1] are a result of complex and interacting processes. They usually intersect with a range of other complex, interacting stresses (e.g. HIV/Aids, environmental degradation, etc.), thus requiring that teaching, learning and curriculum development offer multidisciplinary, interdisciplinary and transdisciplinary approaches in order to adapt to climate change. In South Africa, climate change and the associated impacts are notable challenges, with some modelled climate projections indicating substantial warming (DEA, 2013). In the African case, projections indicate warming that is more than double the global temperature average (see the various IPCC reports). What will it take to develop a citizenry that is enabled and robust, given local vulnerabilities to climate change in South Africa? We argue that a comprehensive and meaningful education, spanning early to adult learning experiences, is key in developing the agency (O'Brien, 2015) required to 'live' effectively with climate change.

Several educational experts (e.g. Wals, Jickling, Lotz-Sisitka, Schudel & O'Donoghue, among others) working on knowledge domains linked to sustainability, including climate change, repeatedly call for a change in the way we 'think' and arguably 'feel' about such issues. Wals (2014), for example, notes that 'addressing climate change … requires a change of mind', adding that, 'at the end of the day, the climate problem is as much in between our ears, as it is between the North and South Poles' (Wals, 2014, press release).

Most environmental education focuses on changing behaviour (Wals, 2011). However, the changes we require to help tackle complex challenges such as climate change involve doing more than just raising awareness and changing attitudes (Wals, 2011:179; O'Brien, 2015). Rather, what may be required is building critical-thinking capacity (which some have argued should be 'radical' (O'Brien *et al.*, 2013)) that will enable citizens to understand what is going on in society, enable critical questions to be asked, and will determine and spur on action (Mayer & Tschapka, 2008; Jickling & Wals, 2008 – cited in Wals, 2011:179).

In her provocative book, *The watchman's rattle: Thinking our way out of extinction*, Costa (2010) illustrates that civilisations which failed to navigate complex stresses have usually collapsed more often because they relied on 'beliefs' (many poorly aligned to problems) as opposed to innovative thinking. She argues that, by focusing on insights and other cognitive abilities, humans can surmount cognitive limitations that may be acting as a gridlock to positive change. However, how does one design a learning journey that can enable knowing core 'scientific' content BUT one that also includes learning that enables critical thinking and can be used to assist in probing some 'deeper' issues (including belief and value systems) that may be mixed up in complex, messy and often entangled sociopolitical contexts? How does one begin to think about learning, teaching

and education (Sterling, 2001, 2004) that can expose us all to more critical and reflexive thinking about climate change? In the unfolding cases below, we provide some guidelines on how one can navigate one's way through a world buffeted by a changing climate.

Towards a Theory of Change

Educating and training the next generation of learners (e.g. university-level graduates; teachers as well as facilitators of learning; young school-going learners; and adult learners), we suggest, will require more than a mere realignment of the curriculum, for example by marrying a 'bit of biophysical science' with a 'bit of social science/development studies'. Educating the next generation of scholars and citizens to both understand knowledge content about the complex climate system and to be 'emancipated' (Wals, 2011), and to begin to think about how and what we can do about climate change (e.g. Folke, 2006; O'Brien, 2015), will require carefully rethinking paradigms and ways in which curricula and knowledge about climate change are currently framed. Such efforts are necessary so that we can create a cohort of flexible, interactive thinkers and doers (Mezirow, 2000; Fazey *et al.*, 2007; Fazey, 2010; Wals, 2010; O'Brien *et al.*, 2013; O'Brien, 2015). These knowledge content domains and curricula will not only require knowledge and skills usually vested in local contexts (e.g. the challenging education system in South Africa) and provided by established 'centres of learning', for instance a school or university, but will also require broader approaches that are mindful, informed, and open to the needs of society and the wider environmental context in which decision-making occurs (e.g. citizen science) (Sterling, 2001, 2004; Jasanoff, 2010; Wals, 2010, 2011, 2014; Muhar, Visser & Van Breda, 2013).

Approaches for thinking about what it may take therefore also need to include ways to embed various inputs, development needs and expectations from a variety of actors, many located outside centres of learning, in the curriculum (a transdisciplinary approach – TD) (Thompson-Klein, 2010). Integration for climate change learning thus entails integrating across 'traditional' school and university disciplinary silos (e.g. biology, physics, economics and law) and developing an educational space that allows for co-engagement of both world and personal views in relation to the world in which we live (Sterling, 2001; Fazey, 2010; O'Brien *et al.*, 2013:49; O'Brien, 2015). Recently, calls have been made both internationally and locally for transforming the current framing of 'climate change' knowledge. The complex environmental and social challenges of the 21st century cannot be addressed with the approaches of the past, and several authors are calling for a different approach to education and capacity-building (O'Brien *et al.*, 2013). 'In fact, it has been argued that nothing less than a "revolution" in education and capacity building is needed to confront the challenges posed by global environmental change' (RESCUE, 2009; O Brien *et al.*, 2013:49). Such an appreciation for a more 'open knowledge system' rather than a 'closed, uniform, linear system' includes a more holistic perspective on the complex environmental challenges facing society (RESCUE, 2011; (Kagawa & Selby, 2012; O'Brien *et al.*, 2013:49; O'Brien, 2015).

A more 'transgressive' process of educational engagement WITH human conduct, emerging matters of concern and the common good is arguably required for meaningful adaptation to

climate change (O'Donoghue, 2014). Such learning journeys will include the importance of 'knowledge-informed learning sequences to enable better-situated knowledge acquisition that enables higher order critical thinking … in [the] context of BOTH schooling and wider multi-stakeholder reflexive learning in a changing world' (O'Donoghue, 2014:22–23). Higher-order thinking, however, requires interrogation of the 'interior' perspectives (religious meaning, aesthetic experience, emotional responses, and ethical and cultural values) (Esbjörn-Hargens, 2010; Hampson & Rich-Tolsma, n.d.) that all shape our constructions of meaning. How these perspectives, and reframing of perspectives, enable personal actions for change thus becomes as important as content knowledge about 'global warming' and about what global average temperature is best for the planet.

Transdisciplinarity (Thompson-Klein, 2010), integral thinking (e.g. Reams, 2007 & O'Brien *et al.*, 2013) and transformative learning (e.g. Mezirow, 1997; Taylor, 2007; Kitchenham, 2008) are some approaches that can be used to provide opportunities for societally relevant climate change learning. World views, including those linked to climate change, are carved out, in part, by schools and universities (Wals, 2010). Increasingly, the messy world we live in also requires that one embraces a range of additional views to one's own personal views from various epistemic communities, including those that enable the 'transformative regeneration of perspectives' (Scharmer, 2009) and transdisciplinary approaches (Funtowicz & Ravetz, 1993). Such approaches can lead one to search 'outside' the confines of traditional sites of formal learning, such as schools and universities, to begin to find out what epistemic knowledge is 'out there' and how to include such knowledge credibly within curriculum and learning contexts (see, for example, Jickling & Wals, 2008 who argue that universities, in particular, have a responsibility for creating and developing sustainability competencies) so that changes in thinking on climate change and other environmental concerns can be enabled:

> The student encountering transformative learning is no longer a mere educational consumer, but rather a transdisciplinary scientist-scholar-practitioner deeply engaged in self-determination and the apt transformation of their world … analogously, the transformative educator is no longer a mere technician charged with administering an educational commodity … [but with] the teacher as catalyst for transformation. (Hampson & Rich-Tolsma, n.d.:12–13)

In almost all cases, as is expanded on below, a participatory and inclusive approach is fundamental, that is, where the 'teacher' acts as a facilitator and co-generator of knowledge and not as a 'font of wisdom', imparting only content knowledge to passive learners.

Transformative Education, Integral Thinking and Transdisciplinarity

The recognition of the need for effective and transformative education for change has grown (e.g. Morin, 1999; Taylor, 2007; Kitchenham, 2008). Internationally, recognition of the need for education as a central component of sustainable development (SD) has been acknowledged (O'Brien *et al.*, 2013; O'Donoghue, 2014). Key elements include being able to learn in

order to *know*, to *do* and to *be able to transform self and society* (Combes, 2006; O'Brien *et al.*, 2013). Renewed commitments to enhanced training and the development of curricula for sustainability were also recently made an outcome of Shaping the Future We Want (UNESCO, 2014).

Alongside the recognition of SD, there has also been a growing acknowledgement that systems that sustain our planet, including complex socio-ecological systems, should include a range of 'knowledges', including those informed from an African perspective – such as local and indigenous knowledge (e.g. Leemans, 2009; Rockström *et al.*, 2009; Reid *et al.*, 2010; O'Brien *et al.*, 2013). In addition to such approaches, one will also have to focus attention on the development of new capabilities, including humility and openness towards other systems of thought and sources of knowledge (Wickson, Carew & Russell, 2006; Jasanoff, 2010; RESCUE, 2012), as well as ensure greater attentiveness to social and self-learning (Esbjörn-Hargens, 2010; Wals, 2010). Expanded notions of education for change, including such reflexive, humble learning approaches, can be framed as a focus on: knowledge information – drawn from systems science and considerations of ethical issues; values – practices giving rise to matters of concern; and actions – assessing change practices (for further details, see: O'Donoghue, 2014; Schudel, 2014).

Most centres of learning, including schools, universities and research institutes, are, however, very limited in their ability to deliver such interdisciplinary and transdisciplinary knowledge needed to address environmental problems (Wals, 2010, 2011). Few have approached knowledge from a transdisciplinary perspective, with some notable exceptions. Internationally (e.g. Arizona State University) and locally (e.g. the University of Stellenbosch), higher education institutions are enabling their learners to grapple with 'real-world realities' in addition to academic and theoretical, 'head-space' knowledge (Wickson, Carew & Russell, 2006). Locally, little substantial evidence is available relating to cases of what 'transdisciplinarity is' in South Africa (Dhansay *et al.*, 2015). Clearly, greater efforts need to be made in order to enable a more expansive shift in thinking in these arenas.

Given these observations and the dearth of any shared, local climate change narratives on more innovative learning and teaching approaches, we felt compelled to begin a discussion on such themes, particularly in respect of learning and teaching about climate change (both about and for climate change – e.g. adaptation) in a range of settings in South Africa. We have been engaged in several such activities that have centred on the heightened relevance of teaching and learning for climate change. Vogel and Misser, for example, have been working on developing teacher materials for some time and have been actively working on the facilitating of both materials development and teacher workshops through EnviroTeach (www.envrioteach.co.za) and Fundisa for Change (www.fundisaforchange.co.za). Vogel and Schwaibold, operating in the tertiary academic space at the University of the Witwatersrand, are engaged in the ACCAI network (http:www.accai.net), funded by the Open Society Foundations. The ACCAI network includes a number of universities (e.g. the University of the Witwatersrand, the University of Nigeria, the University of Ghana, the University of Dar es Salaam and the University of Stellenbosch) that have been supported to enable a postgraduate curriculum to be developed focusing specifically on climate change adaptation.

Through these varied efforts described above, the common aim was to improve both on materials development for climate change and to stimulate conversations and efforts for a transformative learning approach around climate change. The remainder of the paper narrates this journey, examining emerging successes and challenges associated with such efforts.

Beginning a 'Change Journey' for Climate Change – Some Cases and Methods

Mindful of the wealth of research on transformative learning, we adopted some of the ideas underpinning the thinking in transformative learning and tried to provide an enabling environment through both a materials development approach (i.e. through learning materials developed to supplement and to inform teachers of climate change modules in schools) and learning *for* climate change through curriculum change (e.g. through a new course introduced at the postgraduate level for university leaners). We used a mixed set of approaches and methods, explained in more detail below, to begin to examine the challenge of developing interesting curricula for climate change. Such mixed set included transformative learning, integral theory, and transdisciplinary approaches in South Africa.

Adapting Transformative Learning Approaches for Climate Change

The transformative learning approach (e.g. Mezirow, 1997) includes a range of developments in transformative learning that have occurred over time (e.g. Taylor, 2007; Kitchenham, 2008). Transformative learning for social and personal change includes an understanding that learning is 'the process of using a prior interpretation to construe a new or revised interpretation of the meaning of one's experience in order to guide future action' (Mezirow, as cited in Taylor, 2007:173). Using such an approach, educators engaged in the facilitation of transformative learning try to assist their learners to become aware and critical of their own assumptions and the assumptions of others, and thus engage in more critical, reflexive ways of learning and thinking (Mezirow, 1997:10). Such learning is complex and multifaceted and has been built on the influences of Freire's (1970) conscientisation work, Habermas's (1971) domains of learning, and Kuhn's (1962) earlier thinking on paradigms (for details, see: Kitchenham, 2010:105).

Various methods can be used to enable transformative learning, but 'the focus is on discovering the context of ideas and the *belief systems* that shape the way we think … and imagining alternative perspectives' (Mezirow, 1997:11). Mindful of the overarching challenge that climate change knowledge alone will be insufficient to develop the change that may be needed to adapt to climate change (see O'Brien *et al.*, 2013), we embarked on a series of materials and curriculum design efforts to develop agency in learners (O'Brien, 2015) to 'live with change' (i.e. mitigate and adapt to climate change). An 'action–research approach' was followed (e.g. by developing a set of materials compiled as EnviroTeach (Figure 1) and then testing these materials with educators). Following this stage, an expanded exemplar, undertaken as part of Fundisa for Change, was also created. These Fundisa materials were then trialled through a series of interactions (see details below), including the use of various participative methods.

Developing Teaching and Learning for Climate Change – Background to the Development of Learning Materials

The Department of Basic Education in South Africa has undertaken a revised-curriculum process known as CAPS (Curriculum and Assessment Policy), with a strong emphasis on content knowledge. Given the dearth of CAPS-relevant materials for teachers and facilitators (for more details, see: Lotz–Sisitka, 2011), ongoing development of a set of materials, including EnviroTeach and the creation of a Teachers' Development Network (TDN), has begun with a range of partners (see www.fundisaforchange.co.za), many from higher learning, with which two of the authors are associated (Vogel & Misser).

The materials development process (see the immediately following two subsections) was thus spearheaded by activities that included those of the Delta Environmental Centre (the drivers of the EnviroTeach work) and encompassed the Training of Trainers programme (Fundisa for Change), linked to Teacher Education Programmes led by Rhodes University. Exemplars, including one for climate change (compiled by Vogel), were designed as part of Fundisa for Change, focusing on content knowledge of climate change and also on developing leadership and deeper learning among teachers and students for the future (CAPS ++ or CAPS plus plus) (Lotz–Sisitka, 2011; Schudel, 2014). Finally, a separate effort that focused more on tertiary-level education is presented below and entails a university-based curriculum effort involving Vogel and Schwaibold. This builds on some of the ideas developed in the wider network.

Development of EnviroTeach materials

The first 'co-engaged mode', working with a range of inputs, is the development of teaching materials/guides on climate change for mainly *high school teachers* that have been freely distributed to approximately 50 000 schools in the country as EnviroTeach (www.enviroteach.co.za). The purpose of these materials is to provide critical resources for teachers who have limited access to teaching, training and facilitation materials on climate change. EnviroTeach is sponsored by the Department of Environmental Affairs, South Africa, with support from the Embassy of the Federal Republic of Germany and the British High Commission. The content knowledge that has been produced in two issues of EnviroTeach focuses on the following themes: curriculum knowledge (content on climate change is linked to the Grade 10 curriculum in the secondary school system) (first in the series); aspects of transformative learning relating to energy transformation and the food/water/energy nexus (second EnviroTeach issue); and actions for climate change (final issue currently in preparation). Materials are usually co-generated with educators (e.g. with teachers, some with over 30 years of teaching experience, and many of whom are drawn from local schools).

The EnviroTeach content materials in the two issues in circulation were then trialled, at a workshop held at Delta Environmental Centre, with Department of Education officials supporting Life Sciences and Geography and educators from schools. Educators and officials engaged in deliberative processes for deconstructing their own frames of reference and understanding of climate change through a systems approach.

Tools such as the Iceberg Model and participation in dialogues (e.g. with Vogel – a climate change scientist and facilitator of the workshop – and their peers) were used to begin to test the usefulness of the materials that had been developed by EnviroTeach. The focus in these materials and the trial was on expanding learners' climate science knowledge and exploring assumptions and beliefs about climate change, with a specific section on deliberative learning. Details of these cases are not provided here, for the aim in this paper is to trace an expansive set of approaches that can be tried. See Figure 1 (on the next page) for an overview of the knowledge domains explored.

Materials developed in the EnviroTeach volumes, including inputs from the workshop described above, were then expanded for the development of the Fundisa for Change first exemplar on climate change.

Development of Fundisa for Change materials

In the second series of activities, a comprehensive teaching series, one of which focused on climate change and expanding on the EnviroTeach materials development outlined above, was prepared as part of the Fundisa for Change TDN. Partners relevant to the materials development for climate change in the Fundisa network included the Delta Environmental Centre in Johannesburg, the South African National Biodiversity Institute (SANBI) and South African National Parks (SANParks) (see the full set of Fundisa partners at the fundisaforchange. co.za website). The rationale for such effort is that, owing to the vast amount of knowledge content that some subjects in the new curriculum (CAPS) require (e.g. over 50% content that is 'environmental'), a set of exemplars was deemed necessary for educators and for trainers of facilitators focusing on knowledge, methods and assessment practices, particularly for cases with a deficit of learning materials (see: Lotz-Sisitka, 2011; Schudel, 2014). In the case of the climate change exemplar (which was the first to be developed by the network), the approach was to explore aspects of climate change that included an emphasis on basic climate change content knowledge (e.g. with energy transformation used as a unifying theme), as well as move towards aspects of transformative thinking on climate change (e.g. futures thinking as outlined above).

Trialling and testing the materials developed

Testing and improving the materials developed for the Fundisa for Change exemplar required working with 'trainers of trainers' or educators. To this end, educators were invited to participate in a series of meetings. Engagement with the Fundisa for Change materials was undertaken in partnership with the Department of Education in Mpumalanga. Educators from remote areas, including Volksrust, Piet Retief, Secunda, Bethal and Standerton in South Africa, were invited to help to engage with the materials developed through a series of interactions that required repeat visits (e.g. on-site and off-site reflection and learning; three days of focused engagements; intervening weeks to reflect and experiment with lessons. etc.; two days reconvening and meeting, followed by further time to reflect on the materials and use them in classrooms; and a final day of consolidation and meeting). The entire process entailed three months of interactions.

Tasks undertaken included the creation of lessons that could build on the materials provided and the keeping of a journal, in which participants could reflect on their learning journey. The average teaching experience of the educators in the group was ten years. All the educators

Figure 1. Example of contents page of EnviroTeach guide distributed to schools in South Africa

were senior geography educators in their schools. In the group there was one principal and two deputy principals from the schools represented. The subject advisor for geography for the district also participated as a participant on the course, because she wanted to be in a better position to support the teachers.

Through engagement, in a combination of situated learning experiences, supported by 'reflexive questions' and critical engagement with the content, some educators felt they were able to 'link climate change concepts to real-life situations'. Educators were asked to focus on their contexts of learning, their school setting, etc. In most cases, 'meaning-making' was achieved by the facilitator introducing a task and then, through group work and dialogues between participants, an open 'safe space' was created where ideas were shared. Part of the training was also focused on the improved assessment of learners.

In trying to explore more personal approaches and world views on climate change in keeping with a more transformative learning frame, a series of 'futures scenarios' (e.g. O'Brien *et al.*, 2013) and a form of pre-sensing for climate change (Scharmer, 2009) (Figure 1) were also included in the first EnviroTeach edition (2012, Vol. 20). This 'futures' exercise was then piloted with a range of learners as opportunities presented themselves (e.g. through interactions in formal education settings with learners ranging from ten years of age and older to adult learners, including qualified lawyers enrolled for a university course module and teachers training for higher education components). Futures thinking can be challenging (see: Schreiner, Henriksen & Hansen, 2005) and indeed a 'disorientating dilemma' (Mezirow, expanded on in Kitchenham, 2008, Table 1 – Ten phases of transformative learning). Such exercises can enable learners to think more 'carefully about the present' and deliberate future change.

In these sessions, learners are asked to consider states of the environment they currently 'know' and then to project their thinking forward to what they can imagine their environment may be in 20 years' time. Typical questions include: 'Draw the world as you see it now'. Learners are encouraged to only 'draw' and 'illustrate' their thinking graphically. Discussion then focuses on the causal factors shaping change. Learners are then asked to draw the world as they 'want' it or 'aspire' it to be in 20 years' time. Such efforts usually produce very negative illustrations of the world as it is currently experienced (images of pollution, degradation, crime, poverty, global warming), with more positive imagery for the projected 'future'. Of interest is the discussion that then ensues as to what can be changed to avert a future that may be negative and unsustainable, etc. Irrespective of age and class, the move to a more positive 'world' view in the future is common to all.

University-based case study – the case from the University of the Witwatersrand, Johannesburg

Finally, the third case, focusing on curriculum development, was started at the University of the Witwatersrand in 2011 with the aim of creating a new interdisciplinary and transdisciplinary curriculum for global change at masters level. Here, we report on the process undertaken only at the University of the Witwatersrand (for examples elsewhere, also see: Scholes, Crouch, Erasmus, Schwaibold & Voge, 2013). Various other developments among members of the ACCAI network are ongoing (see www.accai.net).

Interdisciplinarity and transdisciplinarity are often acknowledged as being valuable at a tertiary education level, yet universities still tend to teach and work in disciplinary 'silos' without preparing students for the reality of the working world where, in most cases, mixed-discipline teams are needed to tackle issues such as environmental degradation and climate change (Wals, 2010:380) – 'Universities in particular have a responsibility in creating space for alternative thinking and the emergence of new ideas'. Universities continue to remain stubborn in changing their unidirectional, hierarchical and reproductive approach to teaching (Wals, 2010:381). The result is often heightened conflict, disciplinary clashes and science-based solutions (which are often unsustainable or impractical) to global challenges that are by no means solvable only with scientific knowledge and understanding.

The method chosen to try to 'expand' the thinking on climate change and knowledge as presented in the University involved a transdisciplinary design process where one member of the team spent time engaging with other educators across the world and with local actors to gain some ideas on learning for sustainability given change. Following an in-depth assessment of various curricula offered at postgraduate level around the world (consisting of analyses of curricula and interviews with programme coordinators), both the strengths and shortfalls of these programmes were identified with a view to informing local curriculum design at the University.

Several educators in the University then met in a series of meetings to discuss, share concerns and challenges, and begin to plan the curriculum (for more details, see: Taylor, Schwaibold & Watson, 2015). Participants involved in curriculum development at the postgraduate level were also exposed to a co-design process at the University that tried to avoid merely 'clipping together' a number of courses. Several additional meetings and workshops spanning the period 2011 to 2013 were held with the staff of various departments and faculties to co-design an integrated curriculum and to start brainstorming some ideas for a 'sustainability' curriculum at the University, with a strong focus on climate change. One exposure in particular was working on the educators' 'own' personal belief systems and how these may prevent the creation of a more 'transgressive' curriculum (Wals, 2010; O'Donoghue, 2014; Taylor *et al.*, 2015. Working with two international colleagues who are experts in transgressive, educational-learning approaches, including integral theory approaches to climate, a workshop/retreat was co-designed. This workshop/retreat was offered to University staff engaged in climate change teaching and was held off the main campus.

Participants were tasked to focus on their own disciplinary, cultural and personal beliefs and values to enable them to see how these affected their work on the curriculum (with regard to bias towards certain disciplines, right as opposed to wrong, becoming defensive, feeling criticised rather than seeing the value of other contributions, etc.). Participants were exposed to several issues at a very personal level that enabled them to see how these beliefs were either hindering or 'sabotaging' interdisciplinary/transdisciplinary work (Taylor *et al.*, 2015).

To be able to successfully develop a truly interdisciplinary curriculum required a multidisciplinary team of academics to ensure: (a) that the various discipline perspectives are represented in the curriculum; and (b) to ensure support from the various schools and faculties represented on the team. A significant paradigm shift was, however, necessary to create the space

for innovation and for the team to experience what it would like its new cohort of students to experience (see Taylor *et al.*, 2015).

The product of these various interactions is a University-endorsed Masters in Interdisciplinary Global Change Studies that consists of a core interdisciplinary global change course and four additional courses to be chosen from a range of global change-related courses offered by various faculties. While the additional courses are aimed at strengthening the students' knowledge in selected areas (such as business and climate change, environmental sociology, sustainable cities, biodiversity and climate change, etc.), the focus of the core course is less on knowledge-building and more on students developing their own personal competencies that are considered important for the development of sustainable, long-term adaptation strategies (competencies of good sustainability leaders – Brown, 2011; O'Donoghue, 2014; O'Brien, 2015). Key competencies include: Working in mixed-discipline groups; understanding the importance of mixed-discipline approaches to climate change adaptation by analysing selected case studies (related to, for example, sustainable cities, food security, finance and economics) informed from the perspective of a variety of disciplines/viewpoints to gain a more holistic understanding of the issues at hand (using tools such as systems thinking and the integral framework); and, most importantly, learning more about their own disciplinary, cultural and personal beliefs and values in different situations to enable them to better understand how adaptation strategies may or may not succeed in a given stakeholder group (using approaches such as spiral dynamics together with group and one-on-one coaching sessions). The core course is run over five four-day sessions. This allows for gradual reflection, between sessions, on newly gained insights.

Emerging Findings and Challenges

Results from the emerging efforts described above to effectively mainstream climate change education across a range of learning 'levels', are presented below. The findings, where applicable, are centred on an integrative learning and curriculum design approach.

The responses to the materials development efforts captured through the EnviroTeach and the Fundisa climate change exemplar include several positive responses. Educators and education department officials interviewed noted that the concepts in the arena of climate change (e.g. adaptation, resilience and mitigation) were relatively new to them, as this was not part of the training they had undergone to be an educator. Through engaging with the materials, the educators and officials felt more 'confident' because the climate change knowledge was made more accessible to them.

Stimulated by their experience, educators also embarked on change projects in their schools by engaging learners in understanding challenges (including those relating to energy and water) in their own schools and in innovating alternative options for energy and water management. Schools also developed a water and energy policy to guide their practices as a school.

Further realisations of the integrated nature and framing of 'systems' knowledge required for climate change were also noted (Jickling and Wals, 2008). One subject advisor from the Department of Education, for example, observed that 'climate change is not separated from the content we teach. It is an integral part of the content we teach'.

Other observations included, firstly, those from the EnviroTeach and Fundisa materials development projects, and, secondly, reflections on the University curriculum effort. These include better understanding of content knowledge and the beginnings of a transformative awakening that there is more to climate change than just a focus on 'temperature' and 'greenhouse gases':

1. The **training of teachers in both the use of EnviroTeach and the Fundisa for Change exemplar materials on climate change** was very well received, but a number of challenges also emerged. Teachers welcomed the content and found working with various texts and a comprehensive assessment of climate change exciting, including some very basic explorations into scenarios thinking, challenging personal belief systems, and hopes and aspirations for a 'sustainable planet'. Such engagements between teachers and scientists have also been found to be rewarding in other contexts, for instance Europe (Léna, 2009).
   • *Reading and comprehension:* Teachers struggled with the reading provided, of which there was a fair amount during the Delta Environmental Centre course. They seemed to struggle with larger comprehensive documents, and with working through complete documents.
   • *Language barriers:* Because some high school teachers came from rural areas, language was an issue in accessing both content materials and open debates on values and cultural views on climate change.
   • *Creating active agency:* The exemplar and Delta Centre training course seemed to make the teachers feel like professionals by providing them with agency (O'Brien, 2015), which contributed to their intrinsic motivation. Examples of responses from teachers' learning journals included the following:

   'I would like to make a difference in my community [regarding] climate change.'

   'I think I can work with developing individual strategies to fight [for] climate change.'

   'I have observed as a teacher [that] it is important to venture [out using] a variety of teaching methods.'

   'I would like to arouse awareness of individual contributions to climate change.'

   While difficult to measure, evidence of some 'deeper' transformative thinking that may have emerged includes the following responses, captured in educators' journals, that suggest some progression to more critical and deeper-level thinking:

   'Sustainability – for the first time I could relate it to [the] environment in a good way.'

'Superb – it touched my intellect, heart and hands. I got knowledge, my attitude towards the environment changed and I practised skills that can be used in my class.'

'The methodology, activities and flexibility of the facilitator [were] so good.'

'Sustainability – whatever I do has consequences either positive or negative and will affect my life and the way I live. I have to conserve the little that I have and educate my learners to do the same.'

'I still have a lot to learn about the environment, as I was talking [about the] environment in a different way before. I [did] not [know] about integrating the environment with the curriculum.'

2. At the **University level,** the curriculum development and teaching team gained insights, through the retreat/workshop, into their own limited perspectives, blind spots, judgements concerning others and the project, the motivations of others in the team and the University as a whole, as well as their own and others' resistance to change. There were initial reservations on the part of some team members to a more personal and deeper learning approach (e.g. using integral theory approaches). However, the progress made within just a few days at the retreat allowed the team to inform its approach to the project, for example by accepting comments made as 'contributions to rather than contradictions of' their own ideas, valuing different viewpoints, and understanding own beliefs that may impede the process.

The intervention provided various tools to envisage a *new curriculum* that is now being offered by the University. Faculty members from various departments now teach willingly regarding this new course. After two years of running this curriculum, it is still being further developed with broader engagement across faculties based on our experiences as well as student feedback. Overall, the first two years have already generated very positive student responses, and most students agree that they have gained valuable insights into their own beliefs and values which will allow them to better understand and accept the viewpoints and opinions of stakeholders and team members, and to identify, and adjust to, different value systems when discussing issues such as climate change in mixed-stakeholder settings. Statements made by students include the following:

'I felt like a whole new world was opening in front of me and everything I thought I knew was being challenged, and it was wonderful.'

'This course generally affected all of my research and my way of thinking in the other courses I did, and it tied in perfectly. I didn't realise it as it was happening, but now as I look back I can see a transgression in myself, in my way of thinking about everything – problems, research, the world.'

'This course made me question things in a way I never had before, not just by asking questions but [by] really thinking about why things are the way they are and how things are interrelated.'

'I feel like I've really grown as a person, and matured somehow on a different level, but it's hard to put into words.'

'I learnt that group work really [takes] me out of my comfort zone but allows me to learn so much more than when I do things solo. This is especially what I realised when doing the integral theory assignment – I learnt so much from my classmates; they came up with so many things I would never have thought about on my own and also acted as a catalyst for me to come up with different ideas.'

Having seen students grapple with working 'outside their comfort zone', it became very evident that the transformative learning we were trying to achieve would not have happened without challenging the students' way of thinking. While this in itself presented some challenges and resistance, a skilled team, comprising individuals who themselves have gone through a 'learning journey', has been able to create a safe space for students to challenge their own and one another's views of the world and of science and successfully guide the class through a transformative process (Taylor *et al.*, 2015).

Discussion and Conclusions

A 'transformative' approach to understanding and 'living' with and for a more sustainable planet, including enabling more robust living with a climate-changed world, is challenging. Creating exciting knowledge-based teaching materials and an interdisciplinary and transdisciplinary curriculum in various contexts so that civic society can meet and face the challenges of climate change is also difficult and will require a variety of learning approaches and contextual adaptations. Barriers to engagement as well as limitations on time and what is possible, given some major existing challenges in a country such as South Africa, including challenges concerning education, are constraints and persistent obstacles.

The systems one is describing when learning *for and about* climate change are very interconnected and have complex components (Reid *et al.*, 2010; O'Donoghue, 2014; Schudel, 2014). At the same time, the need for the 'transformative' dimension, that, in turn, adds an additional set of complexities, is also key. Social and emotional intelligence, glimpses of which we outlined above in the teachers' and educators' reflections and in the process the academics undertook at the University, is now emerging among students and is, for example, as important as the intellectual abilities to solve problems (Wals, 2010).

Being able to include both a set of skills and knowledge and, at the same time, enabling a critical dialogue and reflection from various perspectives (e.g. transformative learning and not just transmission of knowledge) that may lead to 'new' behaviours and the framing of alternative expressions of meaning remain pivotal in the work being undertaken (e.g. Mezirow, 2000;

Wals, 2010; Hampson & Rich-Talmsa, n.d.). While this has not been fully examined in each of the cases, we believe that a meaningful learning journey has begun, enabled by these processes. Several similar approaches have been, and are being, piloted and tested in South Africa, informed by some of our experiences (Lotz-Sisitka, 2011; Schudel, 2014; O'Donoghue, 2014).

Emerging from this journey are the following critical elements. On the one hand, one needs to avoid a single focus on a 'mind-centred' approach. More integrative and participatory approaches also need to be explored and trialled (e.g. Ferrer, Romero & Albareda, 2010) to enable *learning for change*. A focus on knowledge and content delivery can lead to cognicentrism and the inhibiting of approaches that allow for deep-level thinking, multiple enquiry and collaborative constructions of knowledge. The learners' (both students' and educators') reflections point to such an emerging knowledge concerning climate change, as well as to the understanding that values and beliefs also matter (Brown, 2011; Schreiner *et al.*, 2005; O'Donoghue, 2014; O'Brien, 2015).

Finding the balance between content knowledge and other approaches to self-exploration and learning remains a delicate endeavour. More detail on the work we have shared in this paper needs to be provided and more interrogation awaits to be done as new cohorts of learners are taken into programmes (e.g. in the ACCAI network) and experiences are shared in the various networks (e.g. Fundisa for Change and various EnviroTeach materials packages).

A call for a much more inclusive approach that focuses on understanding science content as well the assumptions held by educators and students, their reasoning, and also a range of moral developments (Schreiner *et al.*, 2005; Wals, 2010; O'Donoghue, 2014) is critical and will, however, take time − it will be a journey of reflection, growth and learning. As we have suggested, some radical reorientation and bravery on the part of educators may be called for − and in a space where one feels safe to enhance one's beliefs and biases. Being able to depart from just a 'content'-dispensing mode is also a challenge − 'Leaving the safe domain of school science culture requires a great effort from a teacher' and arguably in strongly aligned, silo-based domains in universities as well (Schreiner *et al.*, 2005:12).

We acknowledge that much still needs to be done concerning the work that has been started here, particularly around monitoring and evaluation both of the university curriculum and the CAPS curriculum process. Issues that remain as 'works in progress' for further investigation include exploring more deeply the links between content and the ability to innovate and make reasoned choices about teaching approaches, action competence and transformative learning, and moving towards 'learning to know (knowledge), learning to be (identity), learning to live together (social), and learning to do (action) (O'Donoghue, 2014:12). Understanding how and in what contexts such complex epistemological and ontological shifts occur is key for creating the type of change that may be needed to navigate a climate-changed world.

Formal education is one avenue available for possible transformation. Other ways will require incorporating transformative design (e.g. possibly via transdisciplinary efforts − Thompson-Klein, 2010). However, a remaining tension, we argue, is the overwhelming and growing body of knowledge; the needs arising from each discipline; and the tendency for 'quick'-solution roll-outs in, for example, the field of climate change (e.g. 'climate change guidelines'; 'toolkits'; mixing disciplines) that can work against a slower but steadier approach as outlined above that

may, in the end, lead to real transformation. As Scott (2009:158) notes: 'Our methodological portfolios are bulging, and our methods' toolboxes overflow.' We do need to expand outwards from our scientific-realistic perspectives and include other perspectives (e.g. ontological and epistemological), BUT how to be more incisive in our approach, as Scott (2009) notes, remains a fundamental challenge.

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Endnote

1. Note that climate change and climate variability are treated together in this paper and not as separate phenomena.

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