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Contents

Editorial

Ingrid Schudel, Lesley Le Grange and Chris Reddy

The unprecedented levels of human influence on the global environment have drawn the attention of scientists to the extent that in 2002, the Nobel Laureate, Paul Crutzen, helped in postulating a new geological epoch named the Anthropocene (Crutzen, 2002). This idea is not new and Crutzen describes an observation by an Italian geologist named Antonio Stoppani who, in 1873, spoke about an 'anthropozoic era'. Stopanni described this era as a 'new telluric force which in power and universality may be compared to the greater forces of earth' (Stoppani, 1873 in Crutzen, 2002).

Short (2009:7) indicates that this century will be one of continual technological advancement and burdens on the natural world from consumer demands. A citizenry capable of understanding the complexity of environmental issues and actively participating in their resolution is vital. Education approaches might therefore need to place renewed emphasis on the issues of the day, and to contribute to the resolution and prevention of both current and future environmental problems.

The education community's most recent international policy guide is the *Education 2030: Incheon Declaration and Framework for Action* (UNESCO, 2016). This document links the concept of quality education to education for sustainable development (ESD), with the argument that ESD has the potential to enrich acquisition of other foundational competences such as literacy and numeracy. The *Education 2030* framework responds to the recently defined Sustainable Development Goals and centres on Sustainable Development Goal 4, which aims to 'Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all' (United Nations, 2015:12). This goal includes a target on ESD in a call for all learners across the world to 'acquire knowledge and skills needed to promote sustainable development' (United Nations, 2015:15). This target is a springboard for interaction with the other 16 Sustainable Development Goals, which all seek to set the world on a more sustainable path.

In this special edition of the journal, authors have reflected on different aspects of education – its purpose, intended learning outcomes, content knowledge, pedagogy and epistemological underpinnings. The focus has been mainly on teacher education and schooling in southern Africa, with an emphasis on the relevance of subject content, outcomes and concepts to contemporary challenges – the challenges of the Anthropocene. The feature papers in the journal draw on research from Botswana, Lesotho, Namibia, South Africa, Zambia and Zimbabwe.

The first section of the journal comprises think pieces that are theoretical explorations of how we might rethink curriculum and sustainability in the Anthropocene, making points

which we hope will encourage debate amongst our readership. The following section presents feature articles reporting empirical research related to the 'on-the-ground' sustainability and curriculum challenges amongst the environmental education community in southern Africa. The last section comprises viewpoint articles that are inspired by emerging ideas. We outline the contributions from each paper briefly below.

The think pieces raise critical questions in relation to the (post)human condition, the state of the planet, curriculum and sustainability. In the first think piece, Wayne Hugo uses the graphic images of Goya's and Rubens's paintings of Kronus eating one of his children as a metaphor for the gross inequalities between humans in the Anthropocene – that the current generation is denying their children the possibility of worthwhile choices by handing them an unequal world. Hugo hints at the unsustainability of the widening gap between rich and poor and, in view of this fact, raises the perennial curriculum question, 'what knowledge is most worth learning' – what knowledge should be included in the school curriculum? The images of Kronus could also serve as metaphor of how humans are recklessly consuming the biophysical treasures of the earth through unsustainable lifestyles in an era of consumerism.

In the second think piece, Lesley le Grange avers that we need to rethink sustainability and curriculum in view of a (re)turn to realisms because linguistic poststructuralism is no longer an adequate response to the (post)human predicament. By the (post)human predicament, he refers to the dominance of Anthropos that is destroying the earth's biosphere on the one hand and on the other, the ironic potential of advanced technologies to destroy all life on the planet in the bio-genetic age. He argues that we live in uncertain times that require a rethinking of both sustainability and curriculum. Le Grange proposes improvisational jazz as a metaphor/figuration for a reimagined idea of curriculum.

The first group of research papers in this journal present empirical research providing insight into the challenges of environmental learning from the perspective of teacher professional development in in-service and pre-service contexts. Sirkka Tshiningayamwe presents a case study of a professional learning community with a focus on the biodiversity knowledge of science teachers. The case showed that teachers valued practical knowledge for conducting practical activities and fieldwork related to biodiversity, and that meaningful professional development aligned with teachers' valued functionings can serve as a catalyst for capability development.

The next paper to provide baseline insights into teachers' needs is Callie Loubser and Patrick Simalumba's paper on environmental learning in Grade 8–10 Geography in the Caprivi Region in northern Namibia. This mixed-methods survey provides insights into teachers' knowledge and confidence levels with respect to environmental education policy and in-service training; environmental curriculum topics and contextual responses to these; and the use of support materials, and teaching, learning and assessment practices.

Tshiningayamwe invokes a strong sense of the importance of engaging the teachers themselves in driving teacher professional development. An interesting case of this is the study by Ronicka Mudaly and Raeesa Ismail, who probe teacher agency and identity through their focus on teachers as curriculum innovators. This study, of teachers involved in a Bachelor of Education Honours programme in a South African university, highlights how teachers become self-regulating through developing strategies to actively research topics and deepen their

disciplinary knowledge. It also shows how a contextual review of teacher factors, learner factors, physical resources, school management and school ethos provided teachers with knowledge to teach innovatively, by using existing resources, or leveraging additional resources.

Jesse Schrage and Frans Lenglet present a framework for researching the implementation of EE/ESD in teacher education institutions. The framework also embraces the notion of capability, which the authors relate to the four 'pillars of ESD', and incorporates points similar to those raised by Tshiningayamwe, and Mudaly and Ismail. The framework is an amalgam of three theoretical premises, namely the theory of change, theory of education for sustainable human development and the theory of transformative learning. The authors identify factors that hinder and promote the implementation of ESD by applying the framework to review change-projects in two Botswanan teacher education institutions.

Nthalivi Silo and Mphemelang Ketlhoilwe use a lens of strong sustainability and collective agency to review the implementation of project-based learning as a strategy for introducing ESD. Their study, which also took place in two Botswanan teacher education institutions, highlights aspects of project-based learning that impact on a transformative project outcome as well as on student learning. Their cases illustrated how student teachers elicited learning opportunities and developed their initiative and collaborator practices through participating in environmental projects in the grounds of the institutions. They also illustrate the potential for embedding change-projects in traditional disciplines such as science education while warning that knowledge fragmentation and a culture of mono-disciplinarity can affect the transformative capacity of project-based learning.

One of the foci of the remaining group of feature papers is the integration of critical environmental issues into curricula – a key dimension of ESD highlighted by UNESCO's global action plan (2014). At Copperbelt University in Zambia, Overson Shumba, George Kasali, Yaki Namiluko, Beauty Choobe, Gezile Mbewe, Moola Mutondo and Kenneth Maseka reflect on the integration of socio-scientific issues into science-technology-engineering-mathematics (STEM) curricula. Moving from a focus on the integration of environmental issues, to a focus on the integration of specific local practices in order to deepen knowledge of environmental issues, Tichaona Pesanayi, Lintle Khitsane and Farasten Mashozhera investigate the integration of adaptive practices of water in agricultural science taught in selected primary schools in Lesotho, South Africa and Zimbabwe. One finding of this comparative study is that in South Africa, contrary to the other two countries, the teaching of agriculture and sustainable water use is largely excluded from the primary school curriculum. South Africa might have ignored the importance of this at its peril, which the current drought is highlighting.

The final section in the SAJEE comprises 'viewpoint' papers, which open up opportunities for debate as we pick up new ideas and challenges in our changing international and national contexts. Jannie Pretorius, Okkie Combrinck and Stephan du Toit draw on their own experiences to describe a link between personal aesthetics and an evolutionary or survival perspective on habitat and landscape. This viewpoint could stimulate further research into the authors' suggestion that such a landscape-based aesthetic still resonates with, and should be considered in, a modern society with tendencies to be driven by mechanistic and inorganic technologies.

The viewpoint paper by Christo Fabricius and Samantha McCulloch describes how environmental slogans can be varyingly interpreted within one organisation; and cautions environmentalists about the way in which we use slogans to communicate, market our organisations or causes, and reach out to others. Future research around this topic could explore the relationship between slogans and memes, and investigate environmental examples of the 'hijacking' of memes, both as envisaged by Dawkins and in its modern day interpretation and enactment in social media with its playful, creative and critical potential.

What this special edition indicates is that many students, researchers and educators in southern Africa are grappling with the question of how education should respond to the recognition of the global conditions we may call the Anthropocene. They are asking important questions about the purpose, underlying epistemological and philosophical assumptions, intended learning outcomes, curriculum content and teaching approaches we use. There is much food for thought and readers are encouraged to help us deepen, expand and advance the debate and our empirical explorations of how best to respond to the challenges of the Anthropocene through education. We also encourage readers and future authors to read across this and earlier versions of this journal, as these questions require us to draw with care and consciousness on the work that has come before, as we weave new findings and new insights into our field.

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Think Piece
What Education is of Most Worth in a World Where We are Consuming the Future of our Children?

Wayne Hugo, School of Education and Development,
University of KwaZulu-Natal, South Africa

Abstract

This paper argues that we have to radically rethink the purposes of education in a world that is becoming increasingly unequal as global warming intensifies. It argues that our current generation is taking away worthwhile choices and opportunities from our children by handing them a world that will be more unequal (Picketty, 2013) and hotter (Morris, 2010) than it is now. The author used to hold a position that powerful knowledge was a good overarching response to the issues of inequality in education as it enabled learners from poor backgrounds to escape poverty through knowledge. With global increases in warming and inequality, education needs a far more radical response to these issues. This paper constructs an historical argument that shows why powerful knowledge was such a worthwhile outcome of education by reconstructing Spencer's answer to the question 'what knowledge is of most worth?' (1884). He argued that systematic knowledge was of the most worth and this answer has found strong and well-articulated current support in the work of Michael Young and Joe Muller (2013). This answer makes sense in a world that has a high demand for skills and rewards them with decent occupations and remuneration. However, in a world of increasing inequality and deskilling of jobs, powerful knowledge loses some of its power. Furthermore, with the current inability of humanity to control its acceleration towards heat death, education has to take on a far more radicalising function than that which powerful knowledge can provide. This paper does not suggest what ways we can find out of our current tragic mess, and prefers to prolong the moment of despair; although, it does suggest that processes underway and supported by environmental organisations indicate some ways forward.

Introduction

A painting metaphor captures in two images what the paper argues our current generation is doing to its children. The two terrifying paintings by Goya and Rubens are of an old man consuming his children, taking away their future before they can live it. The central argument of the paper is that our current generation is taking away the life chances of our children's children through ways of living that are resulting in heat death and increased inequality. In such a world, we need to radically rethink some of our answers to the perennial question each generation has to answer – 'what knowledge is of most worth?'

Between 1820 and 1824, Goya, old and infirm, painted 14 private paintings on the interior walls of his villa. The dining room, fittingly, had a painting of Kronus eating one of his children.

When Goya initially bought the villa, he had started with more idyllic scenes, but these were blacked out and replaced by the 'black paintings'. The earlier painting, behind the mad Kronus, was of a dancing figure, but this was macabrely transformed into cannibalistic incest.

Image 1. Goya: *Kronus Devouring His Son* (1823)

We have no insight into what drove Goya's darkening heart but this most private of expressions has survived to become one of his most iconic paintings. It was not meant to survive; no protective layers were added, and it had to be carefully pried off the walls and bonded on canvas for posterity's sake.

The Greek myth of Kronus is about a titan who hears a prophecy that he will be overthrown by one of his children, just as he had overthrown his own father (Uranus) by castrating and imprisoning him. To ensure this does not happen, he devours his children as they are born. However, it is not a new-born infant that Goya depicts, rather a young adult, and it is hard to determine the sex of the already dead body, making it a universal symbol of youth destroyed by an older, madder generation.

There are variations and degrees of madness and insanity. If we compare Goya's Kronus to Rubens' Kronus, painted almost two hundred years earlier, we can get a symbolic comparison of the grades of madness.

Image 2. Rubens: *Kronus Devouring His Son* (1637)

Ruben's Kronus is still in control of his 'wits'. He is a recognisably wise old man gone mad, with the staff and stars still guiding his way. Ruben's own account in a letter to Franciscus Junis is that he followed

> all the examples, the opinions and the tenets promoting the dignity and splendor of the Art of Painting which the ancients enshrined in their literature and which have, to our very great benefit, survived to our day. (Harrison, Wood & Gaiger, 2000:28)

We can see the beautiful and innocent child, still alive, arched towards us, unwittingly experiencing the first horrors of a wise older man beginning to consume him or her. As with Goya, we cannot tell the sex of the child, making him/her a symbol of infancy consumed by an elder generation.

I suggest that we are currently caught between these two images of what the older generation is doing to its young. We are beyond using images of protection, love and care, caught by Morisot's late 19th century painting of a mother peacefully contemplating her beautiful daughter, who is safely ensconced in a cradle.

Image 3. Morisot: *The Cradle* (1872)

As a species, we are not protecting our future progeny, we are consuming them. Morisot's tranquil meditation holds no traction for us in the 21st century; we are not at the cradle with our children, we are between the early reasoned madness of Ruben's Kronus and the crazed insanity of Goya's Kronus. It is in this space that we have to ask 'what education is of the most worth?', repeating the question asked by each generation anew, but this time asking it in radically different times.

We are in dark times. The tales of linear and cumulative growth in reason and wealth that we have comfortly told ourselves since the late 18th century secular 'enlightenment' struggle to hold as we hurtle upwards towards an apocalyptic cliff – or at least that is what want to believe, that we are still hurtling *towards* the cliff, not already *plunging off*. We want to believe that we still have a moment of choice where normal time stops and we have an opening to choose between two paths, one of which is us protecting our young, the other us destroying the future of our young. I don't think that is our choice anymore, we don't have that choice, all we have is the space between Ruben's and Goya's Kronus. It is from despair and not hope that we have to rethink what education is of most worth.

Kronus, Chronos and Kairos

The ancient Greeks had a term for such a time of opportune choice; where normal chronological time stands still – a moment of open possibility that must be taken or lost. They called it *Kairos*, and juxtaposed it to normal time *Chronos*. For the ancient Greek rhetoricians, Kairos was the moment in which a proof was delivered, the moment that brought all the elements of an argument together into a decisive judgement that carried the day. Christians picked up on the term and turned it into an existential decision that must be made by an individual in a time of crisis. So we have the titan Kronus, consuming his children, mixed up with Chronos, the Greek god of chronological time, and both mixed in with Kairos, the supreme moment that must be taken or it is lost. We are in lost times. The moment of Kairos has passed, our actions do not allow for a moment to arise where we can decide to protect our young, we have already consumed that moment. We are not in a world of 'post' this or 'neo' that, we are in a lost world. In this world where we consume the future of our children, what sense can we make of the venerable education question – what knowledge is of most worth? It is an educational question each generation has had to struggle with, but never in the current conditions we have made for ourselves.

To get a handle on how the question has been answered in the past, let's step back for a moment and explore how Herbert Spencer answered this question a hundred years ago when forward and upward progress was a foundational assumption in dominant western societies. Please note that there are many answers given historically to this question. Rousseau, in *Emile* answered it with a civic call; Dewey, in *Democracy and Education* answered it with 'democracy'; Ken Robinson has recently answered the question with 'creativity'; and Nell Noddings with 'care'. In this paper, however, I would like to focus on one specific answer that has been historically strong since Plato's *Republic* – 'powerful knowledge' – and use one of the most profound thinkers of the 19th century to elaborate on it.

Herbert Spencer's Answer to the Question 'What Knowledge is of Most Worth?'

Herbert Spencer was one of the most influential British intellectuals of the 19th century across a number of fields, one being education. In *What knowledge is of most worth*, he outlined the regulative principles of education he reasoned were the most important. Spencer starts with an attack on 'the education of a gentleman' where Latin and Greek is learnt to no practical purpose. He imagines a boy, now grown up, living in a practical adult world, finding his classical education of almost no worth whatsoever:

> in his shop, or his office, in managing his estate or his family, in playing his part as director of a bank or railway, he is very little aided by this knowledge he took so many years to acquire … If we enquire what is the real motive for giving boys a classical education, we find it to be simply conformity to public opinion. (Spencer, 1884:3)

The battle lines are clear. Spencer is not looking for an alliance with traditional forms of education that bring honour and respect, he is out to destroy the old and bring in the new – the question is: what new?

His next move is to ask what principle we can use to determine 'in some rational way what things are really most worth learning' (1884:9). Spencer suggests that we must find a way of putting the principle in as general a way as possible so that it speaks to all of us. He finds such a regulative principle for education in its function to 'prepare us for complete living' (1884:12). As human beings, this is something we all want. It is common to all of us.

But this principle is not enough, it is too general, too vague. What is needed is an ordering of worth from most important to least important (Boltanski & Thevenot, 2006). Spencer provides just such a list:

- Firstly, we need to preserve ourselves, for nothing else is possible (from an anthropocentric perspective) without this base;
- Secondly, we need to secure our means of living through work;
- Thirdly, after securing our own survival and sustaining it through work, we can look towards the survival of our family;
- Fourthly, once our family is secured we can expand outwards to the preservation of the state; and
- Fifthly, only once all of this is secured can we look forward to some leisure activities.

Because of a scarcity of resources and time, it is impossible to do all of these activities all the time in education, so we need to allocate an order of worth, where the most important activities get most of the time and the least important activities least of the time (Boltanski & Thevenot, 2006:17).

But how do we decide what is important within each of these areas, after we have ordered their worth? Spencer argues that all five of the above activities work best with science:

> For direct self preservation, or the maintenance of life and health, the all important knowledge is – Science. For the indirect self preservation which we call gaining a livelihood, the knowledge of greatest value is – Science. For the interpretation of national life, past and present, without which the citizen cannot regulate his conduct, the indispensible key is – Science. Alike for the most perfect production and highest enjoyment of art in all its forms, the needful preparation is still – Science. (Spencer, 1884:84–85)

Spencer has found the most general regulative education principle that speaks to everyone everywhere and ensures a better life for everyone – a common good – and it is 'powerful knowledge', or science located within a free market that allows everyone to compete.

> Necessary and eternal are its truths, all Science concerns all mankind for all time. Equally at present, and in remotest future, must it be of incalculable importance for the regulation of their conduct. (Spencer, 1884:85–86)

What knowledge is of most worth deservedly exists as one of the classics in theorising education and I have not done it justice with this truncated account. Paramount throughout is the principle of *specialisation through science*; whether it be physical science, social science, domestic science, political science, or human science. It is this principle of specialisation through powerful knowledge, Spencer argued, that provides us with the common good all of us need, but have to work very hard to attain. It is this principle that we can use when choosing what should go into the curriculum and what should not; it is this principle that regulates what and how we do education; it is this principle that tells us what knowledge is of most worth. The principle of powerful, systematic, ordered knowledge, placed within a bigger socio-economic world of the free market and competition, Spencer felt, would improve efficiencies and drive progress ever upwards. This is how 'the survival of the fittest' worked – a phrase Spencer used to describe Darwin's Natural Selection and then extrapolated to social and economic forces (Paul, 1988). An education that was scientifically based enabled the survival of the fittest.

This argument made sense in a late 19th century Anglo-American dominated, liberal-capitalist world with exploding economies, increased energy capture, massive innovation and a growing population. However, the negative reality of capitalist growth was always clear to see in that century – it might increase productivity, but it also increased inequality, as Marx pointed out. What was the point of improved productivity if it mostly went to the rich and immiserated the poor? Capitalism had to be radically critiqued and opposed with profoundly alternative models. Science was not enough as a regulating principle of education, there had to be a more radical regulating principle that fundamentally changed the inequalities produced by capitalism. Spencer's answer to the perennial question 'what knowledge is of most worth?' struggled in the face of child labour, tenement squalor and obscene wealth for the few. Radical educators with a strong social justice orientation could not accept a principle of science that ignored the rapid increase in inequality and suffering, and began to push for a strong critique of how science and capitalism worked hand in hand to strip the poor and – as we increasingly began to realise – strip the earth. Then something strange happened to the increasing levels of inequality generated by capitalism in the 19th century: instead of continuing to increase to the point where the only choice would be revolution, as Marx predicted, inequality levels within the more developed capitalist countries started to lessen in the 20th century.

The Kuznets Curve and the Decrease of Inequality with Capitalism

This trend was clearly articulated half way through the 20th century. In 1954, after compiling what was then one of the largest data sets on income inequality, Kuznets gave a presidential address to the American Economic Association on historical trends within income inequality, subsequently published in the *American Economic Review* (1955). The data he had collected, which was most extensive for the United Kingdom and the United States, took the following pattern for the time period 1913–1948, which can be simply caught in the following graph:

Figure 1. Inequality data from Kuznets showing decrease in inequality (1913–1948)
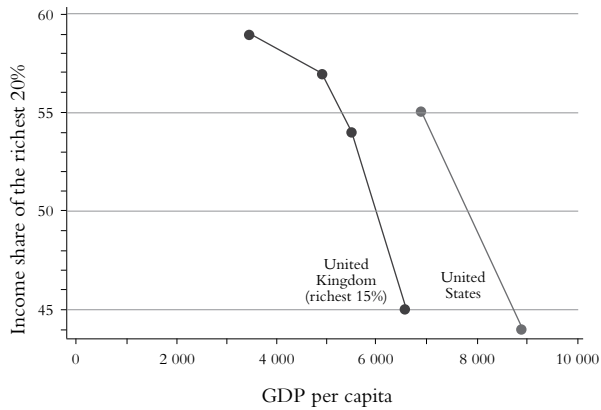
The income share of the richest 20% in both the USA and UK had fallen dramatically as the gross domestic product (GDP) per capita went up. Income inequality between the rich and the poor diminished the more the growth of the economy increased. It was an astonishing finding. As GDP per capita went up, the percentage share of the richest 20% went down. Economic growth (mainly in the West) actually resulted in less economic inequality in those countries. Income growth was rising, but was being increasingly distributed away from the rich and towards the poor using democratic and welfarist policy measures. It was a fairytale ending for the capitalist system in these bounded spaces. This system, with all its selfish profit motives, resulted in a benign distribution, where everyone in these bounded spaces started to benefit, not just the rich. There really seemed to be a hidden hand in capitalism that seemingly took wealth from the rich and trickled it downwards, as Adam Smith had predicted.

Kuznets' conclusion was that industrial development in its early phases had logics that increased income disparity between the rich and the poor; but, at a certain point, the trend reversed itself as the economic system matured, resulting in decreasing levels of income inequality. Marx was right about early capitalist industrialisation increasing inequality, but wrong about the long-term trend in these bounded societal contexts (as income inequality continued at a global scale). This gave an inverted U shape to income inequality within capitalist forms of industrialisation in the West. Please see Picketty's introduction in *Capital in the 21st century* (2014) for a fuller description of what I am simply summarising here.

In a world where burgeoning science and capitalism together actively reduced inequality, it was hard to hold onto a radical critique mindset. Spencer's answer to the question of 'what knowledge is of most worth?' in the societies that were benefitting from this logic – science, science and more science – made sense, as it actively improved production, reduced inequality and increased life chances in these settings.

Figure 2. The Kuznets Curve
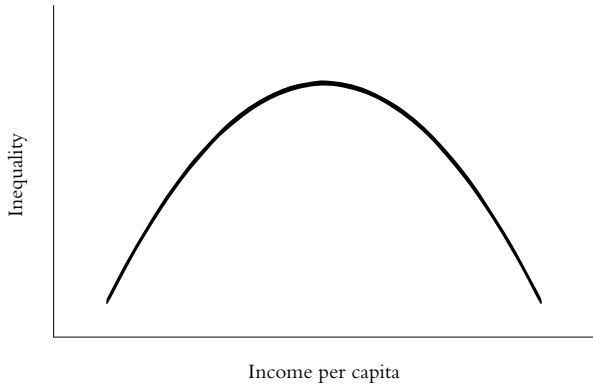
In such a context (that of decreasing inequality and growing production), a child from a poor family who gets a sound education based on powerful knowledge has real prospects of improving his/her lot. The economy needs their specialised skills and is prepared to pay for them. Education acts as a force of convergence, reducing levels of inequality by providing specialised skills that are in demand, no matter if you are rich or poor. In such a context, Spencer's answer of 'science' makes sense. In Kuznets' world of decreasing inequality within a growth of output, education plays an obvious and powerful role as one of the forces enabling at least some convergence between rich and poor, because its effects are clear to see. But Kuznets was writing in a very particular time: the 1950s in Anglo-American environments, with their peculiar need for massive reconstruction after the world wars, which also created considerable growth opportunities as USA expansionism extended to the East (e.g. Japan) in post-war rebuilding efforts. So much had been destroyed, so much needed to be rebuilt, creating a 'new world' of solidarity where all could come together and benefit.

Combine this need for reconstruction in the 1950s with the explosive global growth in production and population, as well as massive improvements in technology, and it becomes clear that if you had a high-level skill then you would be in demand and an education that gave you that skill would also be in demand. Skills are quickly snapped up and rewarded with increased income in a world that is growing economically. Ostensibly, everybody did benefit, and education as a provider of powerful knowledge was therefore seen to be key to increasing income for the poor and lowering the income gap between high earners and low earners. It is deeply ironic that this great take-off in economic productivity is now being used as the possible starting date for the Anthropocene – the period where human activity becomes the dominant influence on climate and the environment.

Inequality in Wealth – Saez, Zucman and Picketty

Kuznets did not have the means or the time to gather data on wealth inequality – on the amount of capital people own *as well as* how much they earn. The very rich mostly do not earn direct incomes from work done, they receive dividends and rents that enable a life of leisure. Measuring income inequality, as Kuznets did, missed the massive wealth the very few own and pass down as dynastic inheritance to their children. The amount of wealth in the world is far more than how much people earn in a given year, and wealth acquisition and growth has much less to do with education. A good education might and should get you a better income, but it does not get you wealthy – that you get from your family and its networks, or if you are one of the exceptional few who 'make it big'.

The simple reason for this is that there is an initial cost to simply reproducing your everyday existence before saving and investment becomes possible. The richer you are, the more you can save and invest. The poorer you are, the more your money goes on food and transport and survival, with nothing left at the end of the month. Middle-income earners can begin to invest and save, but the proportion of their income available for this is limited and takes longer to build up. For the bottom 90%, wealth does not even feature as a possibility, as it is life that is being reproduced, not wealth. For the top 1%, they are able to save and invest around half of their earnings, even with a lavish lifestyle, and pass this lifestyle down to their children, regardless of their education levels (Saez & Zucman, 2014).

Figure 3. Saving rates by wealth class (1913-2012)
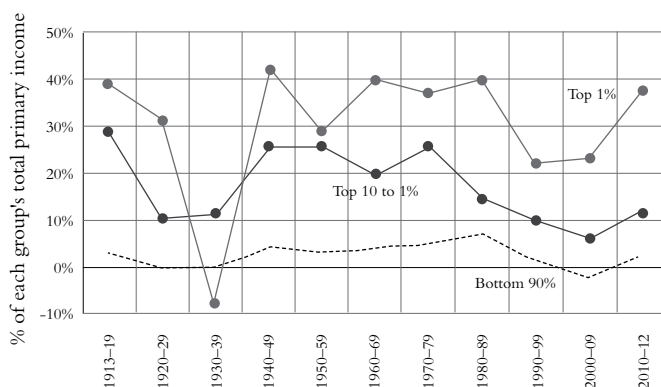
The rich save more as a fraction of their income, except in the 1930s when there was a large dissaving through corporations. NB: The average private saving has been 9.8% over 1913–2013.

If education is one of the major forces of convergence that reduces inequality, then wealth is a major divergent force, as it tends to accumulate in the hands of those who already have it, and stay there. If there is a high rate of return on capital, then the rich get richer and do so in ways that are far out of reach for those earning incomes. Recent studies on the rate of return on capital investment (most famously articulated by Picketty's *Capital*) show that, historically, wealth (or capital) returned 4–5% per year on average.

The rich lived off their investments, and always have done. Education for the rich was about networks, connections and the social dispositions to maintain them; not learning skills or specialising – those are working class and middle class preoccupations that revolve around wage income, not enjoying and protecting capital investments. Spencer's argument for science and competition was strongly convincing for the emerging middle class, but for the wealthy and the social networks they lived in, it was far more important to seem a gentleman or a lady. Two world wars substantially changed this picture, however, with massive amounts of concrete wealth destroyed by bombs and a great depression radically devaluing wealth. The rate of return on capital dropped, and actually fell below the rate of growth of the economy.

In a world of increasing economic growth and decreasing return on capital investments, the role of education as a converging force towards equality was exceptionally enhanced. What you could do became more important than what you had invested, and what you could do was directly related to how good your education was, and specifically what powerful knowledge and skills you had. Then, even better, as the developed world recovered from its great self-destruction, so too did the return on capital slowly improve; this meant that not only did you have a chance to make money, but the returns on your savings began to increase. Spencer's answer to 'what knowledge is of most worth?' strongly resonated in such conditions.

This set of factors, where the annual growth rate of global output was greater than the rate of return on capital, has consistently held through most of the 20th century; from World War I to the early 1970s, according to Saez and Zucman (2014). In this world, powerful knowledge is in high demand, and anyone who has it is venerated and rewarded, enabling a break in the cycles of poverty (where the struggle to reproduce life is overwhelming), towards a world where you start to focus on growing your capital or wealth and benefit from its increasing returns. So, not only are your knowledge and skills in high demand because of the increasing growth rate stimulating demand, but the reward for investing your savings is also increasing, resulting in a double-bonus reward for investing in powerful knowledge. If you want the capitalist version: investment in human capital made sense and offered strong returns; if you want the social-realist version: investment in powerful knowledge made sense and offered improved life chances. If education offered such high returns for most of the 20th century, then why the dystopian beginning to this article?

This long 20th century trend of high growth combined with high returns on investment was not how things had always been, and nor, according to Picketty (2014), is it going to continue (and he can say so, based on a massive data collection on inequality that Kuznets could barely dream of). His findings show that, since the 1970s, divergent forces that seek to widen the inequality gap have taken over, resulting in a macro-economic picture in which the growth rate of global output is again decreasing to levels last seen before the 20th century; while, at the same time, returns on wealth investments are increasing towards the historical average of 4–5%. Basically, this means that the rich will reap rewards from their investments, but not leave any openings for others to get in on the wealth pile, due to low levels of growth. These potent divergent forces that increase inequality have a dramatic impact on the effectiveness of powerful knowledge as a force for convergence.

In a world where the rich are super rich and almost everyone else is relatively poor, the worth of *powerful knowledge* lessens in relation to the *knowledge of the powerful* – the connections of the powerful, the networks of the powerful, the families and friends of the powerful. The loss of power in powerful knowledge is aggravated by continuous 'improvements in technology' that are automating high-level skills through computer programmes, reducing the demand for the high professions (engineering, medicine, accounting, architecture and law) and middle level professions (like teaching). Programmes design houses, build bridges, calculate taxes, spurt out diagnoses, teach lessons, assess lessons, give feedback to lessons. Lawyers, doctors, engineers, architects, accountants, teachers are looking for work, threatened by outsourcing and technological replacements; never mind drivers of trucks and taxis, housekeepers and sex workers. It is not that powerful knowledge is not still important, or that, for some, it offers a chance to escape the cycle of poverty through its powers, as Young and Muller (2013) cogently argue, but the conditions that used to give it so much purchase in the past have changed. It is still a force for convergence, but in a world where forces of divergence are rampant.

With an increasing divide in wealth and a slowing of the growth rate, channels that offer advancement in the world are taken up and dominated by the wealthy and their networks. The best schools, the best universities, the best holiday programmes, the best tutors, the best extra-curricula activities, continuously invested in from birth to death, mean that the few opportunities that there are, are taken by the 'best', and the best is bought. To give poor, working class students the hope that powerful knowledge will get them out of their increasing poverty, is to sell an out-dated 20th century dream. To become a professional is a continuous two-decade investment that involves energy, commitment, community support, family pedagogy, networks and money. To fail at the task leaves you in an indebted world, divorced from your local and located networks. For in a world of increasing wealth gaps and low growth, it is the community you have grown up in that is the safest place to learn in, become a part of and to fight for. It is in the local community that you can find a space to struggle for something new; that is if your community has not been broken down, gentrified, isolated, or subjected to the ravages of pollution and degradation, or demonised.

Nor is there any way we can wish for a return to high growth rate in global output, for that comes with massive consumption of energy, spewing out entropically, increasing the pace of the heat death we are already on the path towards (IPCC, 2014), overwhelming any attempt of our current human systems to cope with it. Any discussion about the increasing inequality within the world and the role education can play in addressing it has to deal with the far bigger issue of our current energy consumption being far larger than an environment conducive to humanity can absorb. It was science that enabled us to capture and use the energy resources of the world built up over millions of years, the science Spencer speaks about so glowingly as ensuring our survival and improving our lives; this science is now a monster god, burning us in its glory. We tell ourselves that this same science will save us, give us the moment of Kairos, where we can make a decision that saves us all; whereas we are all already in hell, except we don't know it yet. And like Dante found, when walking through the circles of the inferno, all he met there still desired their suffering, continued to inflict it on themselves, repeated the same actions, even though it brought pain and pushed them deeper into their own misery.

The Anthropocene and Education

To see this clearly, we need to place Picketty's insight that wealth is again concentrating in the hands of the few to the cost of everyone else with a telling graph constructed by Ian Morris (2010) that shows the sudden and exponential increase in energy capture over the last 300 years in both the East and the West. Increased energy capture allows for massive expansion of population and social development at the same time, as the core needs of energy are provided. It should be a victorious tale of how human ingenuity and scientific innovation have culminated in the most flourishing time for our human species. However, we know what this energy capture has actually resulted in – the threat to the future of the human species on earth, even though we recognise the consequences and are doing it to ourselves.

Figure 4. Eastern and Western energy capture (14 000 BCE to 2000 CE)
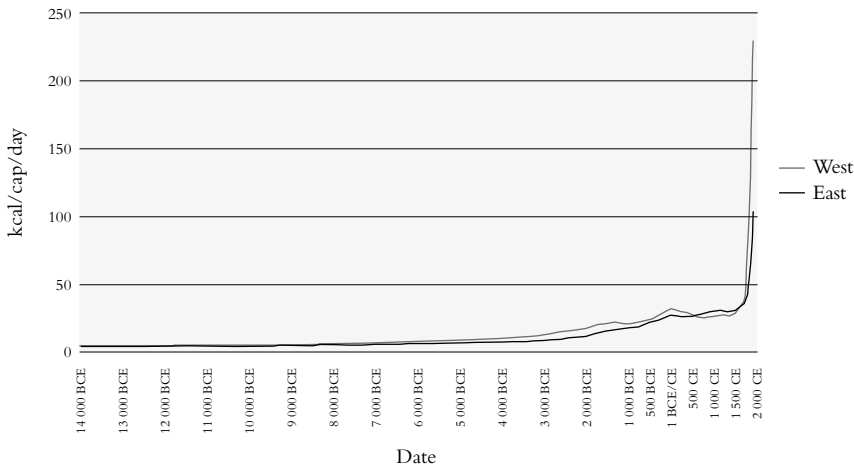
It is in the context of our ability to capture and exploit energy that the human species has become a force to actually change the way the whole physical world functions. It is vital to make a distinction between the Holocene and the Anthropocene at this point (Williams *et.al*, 2016). The Holocene is a geological term for the recent warming period on earth starting around 9700 BCE. This period also coincides with the increasing impact of human kind on earth as its population grew and became urbanised. However, from the industrial revolution in the late 18th century, there has been an ever-increasing explosion of human impact on earth. Since 1964 (my own birthdate), human impact has become even more pronounced, with global rates of extinction, carbon dioxide emissions and rapidly increasing erosion. The old man in the two paintings is also me. But, navel gazing aside, this paper can be simply put as a statement: with the Anthropocene comes a whole new set of radical questions about what education is of most worth. It is not like we, taken as the human species, have used all this energy to ensure increasing equality for all; instead, it is being used to exploit and increase inequality. How can

it be that we are currently in a world that is destroying itself due to massive and polluting consumption of energy, at the same time as ensuring that only the few accumulate all the resources from this consumption?

There are people currently struggling to answer the question 'what knowledge is of most worth in the age of the Anthropocene?' Some, like Ray Kurzweil (2005), push for exponential technological innovation. Others, like Theresa Lloro-Bidart (2016), push for eco-feminist and post humanist political ecology education. This article is torn between discussing what these answers currently are and leaving a genuine space for despair without answers, at least for a while. I would like to stay with the second option, stay caught between growing inequality and heat death. I think we sometimes move too quickly towards answers in the hope of some kind of emotional normalisation in a human world directly focused on self-harm. I would like to remain with the question for a while, but do undertake to attempt my own best answer (along with an account of other answers) in a future issue of the journal.

Conclusion

It becomes clear that our current generation has to answer the question 'what knowledge is of most worth?' in a new, far more radical way than Marx could have imagined; for it is the future of humanity at stake, not just the proletariat, and we are consuming the very possibility of responding to this crisis in the future. The old venerable answer that seemed so new and fresh with Spencer, that attacked and critiqued the even older classical education of the gentleman with a clarion call for progress through powerful knowledge, is now out of date for three main reasons:

- Firstly, it has consumed our future through an omnivorous present that uses every single specialised means it has at its disposal to exploit and capture our world to the point of our own species destruction;
- Secondly, it now exists in a world where the wealthy dominate and the value of powerful knowledge has lost its potency in the widening chasm of inequality; and
- Thirdly, high technology is now devaluing professions with sophisticated algorithms that can do most of the legwork, resulting in many professionals suddenly finding themselves relegated to data entry and a human touch.

We need a new answer, and the space we look for that answer is partly with the people engaged in environmental education, like Professor Heila Lotz-Sisitka and the community surrounding her, and with journals like the *Southern African Journal of Environmental Education* and *Environment and Society*. This does not give me much hope for our future, but it does mean that when the children of our children face the catastrophe we have already created for them, they may at least look back on some of us with something a little milder than hatred and disgust.

Note on the Contributor

Professor Wayne Hugo is an associate professor at the University of Kwa-Zulu Natal's School of Education and Development. He is researching and writing about how we can use education as a force for good in modern times. Email: hugow@ukzn.ac.za

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Think Piece
Sustainability Education
and (Curriculum) Improvisation

Lesley le Grange,
Faculty of Education, Stellenbosch University, South Africa

Abstract

In this article I (re)think sustainability education in view of a (re)turn to realisms because existing philosophies have failed to adequately respond to an impending ecological disaster and the fast pace of new technologies. This historical moment has made geologists posit a new epoch, the Anthropocene. I argue that responses to this historical moment must overcome correlationalism generally, and in particular a narrow form of it called instrumental rationality. Correlationalism means that reality appears only as the correlate of human thought. I suggest that sustainability might be liberated from the fetters of correlationalism by invoking a metaphor from jazz music, improvisation. Improvisation that is anti-correlationalist involves being attuned to the reverberations of the earth, to its materials flows, rhythms and intensities. Moreover, pedagogy as improvisation does not merely use the earth as a stage on which pedagogical acts are performed, but pedagogy is bent by the earth. Moreover, sustainability education involves the development of sensibilities that are an amalgam of visual (videre)*, listening* (sontare) *and feeling* (sentire).

Introduction

Environmental problems have reached unprecedented levels to the extent that it would be reasonable to claim that Earth is on the brink of ecological disaster. This is evidenced by, for example, two recent reports (Rignot *et al.*, 2014; Joughin, Smith & Medley, 2014) which indicate that the Antarctic ice sheet has begun an irreversible process of disintegration. Destruction of the earth's biophysical base should, however, not be viewed in isolation, but understood transversally through recognising the simultaneous destruction/erosion of the two other ecological domains: the social and the mental. In his book entitled *The Three Ecologies*, French psychoanalyst Felix Guattari (2001:41) asserts that there are three interlocking dimensions of the environment: the self, social and nature. In other words, nature cannot be separated from culture and that we need to think transversely if we are to comprehend the interactions between the three interlocking ecological registers. He writes:

> Just as monstrous and mutant algae invade the lagoon of Venice, so our television screens are populated, saturated, by 'degenerate' images and statements. In the field of social ecology, men like Donald Trump are permitted to proliferate freely, like another species of algae, taking over entire districts of New York and Atlantic City; he 'redevelops' by raising rents, thereby driving out tens of thousands of poor families, most of whom are

condemned to homelessness, becoming the equivalent of dead fish of environmental ecology.

Destruction of the three interlocking dimensions of environment has reached unparalleled levels, giving rise to a historical moment, a potentially new geological epoch, the Anthropocene that Braidotti (2013) refers to as 'a bio-genetic age'. The Anthropocene is a peculiar term for some though because in this geological epoch 'non-humans make decisive contact with humans' (Morton, quoted in Payne, 2016:169). Among other developments, this historical moment is witnessing a (re)turn to realisms: a return to critical realism; a turn to speculative realism and matter-realism (new materialisms) because existing philosophies (phenomenology, critical theory and post-structuralism) are no longer adequate for responding to current challenges. As Bryant, Srnicek and Harman (2011:3) write:

> In the face of the ecological crisis, the forward march of neuroscience, the increasingly splintered interpretations of basic physics, and the ongoing breach of the divide between human and machine, there is a growing sense that previous philosophies are incapable of confronting these events.

Moreover, Johnson (2013:5) states that, 'the naturalization of capitalism has made the epistemic limits of critical theory ever more apparent'. He argues that the theories that challenged the limits of the social continuum have ironically succumbed to the very economic analysis they were meant to confront.

A (re)turn to speculative realism, new materialisms (matter-realism) and critical realism is a response to the perceived limits of linguistic (post)structuralisms and other anthropocentric philosophies. All the realisms mentioned are opposed to what is referred to as naïve realism – the idea that an external observer is the locus from which the entire world can be grasped. Speculative and new materialisms are recent responses to the now 'tiresome "Linguistic Turn"' (Bryant *et al.*, 2016:1). Speculative realism denotes a range of thought but, put simply, it is a philosophy that signifies a return to speculating the nature of reality independently of human thought and holds that continental philosophy (phenomenology, structuralism, post-structuralism, deconstruction and postmodernism) has descended into an anti-realist stance in the form of what Meillassoux (2008:5) terms 'correlationism'. Put simply, correlationalism means that reality appears only as the correlate of human thought – the limit of correlationalism is why conventional continental philosophy might be considered anthropocentric. New materialisms represent an interdisciplinary field of inquiry produced by a group of feminist scholars. It short, these scholars share the view that humans are not only socially, discursively and linguistically constructed, but also materially constructed. By material it is meant that human beings are made of the same physical materials as the non-human (more-than-human-world) and that all human systems (including systems of thought) are underpinned by material flows. New materialisms also extend agential capacities to the more-than-human-world.

The historical moment mentioned is also characterised by what Braidotti (2013:1) terms, the 'post-human predicament'. This is because humans have reached a point where as a species

it is not only able to manipulate and control all of life but has the capability to destroy it. Human arrogance or self-esteem has reached its zenith. Yet at the same time the human body (or its parts) is being commodified and the genetic code is now capital. Moreover, non-human objects created by humans threaten to destroy all life including that of humans – objects such as drones, tools of biological warfare, the potential of nanotechnology to produce self-reproducing molecular machines called ecophages, and so on. In a technologically mediated world the boundary between human and machine is becoming blurred. Braidotti (2013:2) avers that it is a condition that 'introduces a qualitative shift in our thinking about what exactly is the basic unit of common reference for our species'. The present condition could also be described as a time of crisis – a crisis of humanism that has reached a tipping point (for more on the crisis of humanism see Le Grange, 2013). Or, as Davidson (2000) suggests, that currently global society is delicately poised on a civilisational threshold similar to that of the feudal era. This is a time when outmoded institutions, values, and systems of thought and their associated dogmas are ripe for transcendence by more relevant systems of organisation and knowledge. In moments such as these, old questions remerge such as the perennial existential question of *how we should live*. So too do educational ones remerge such as, *what is education for* (Orr, 1992) or *what and how we should learn* (Le Grange, 2011). But, times of crisis also present new opportunities, create fresh imaginings and alternative meanings and turns. It is in this context that Hannah Arendt's (1954:193) description of education written in the wake of World War II might be apposite; in particular her references 'love the world', 'undertaking something new', 'something unforeseen by us':

> Education is the point at which we decide whether we love the world enough to assume responsibility for it and by the same token to save it from that ruin which, except for renewal, except for the coming of the new and young, would be inevitable. And education, too, is where we decide whether we love our children enough not to expel them from our world and leave them to their own devices, nor to strike from their hands their chances of undertaking something new, something unforeseen by us.

The post-human condition is characterised by complexity and uncertainty and cannot be engaged with through modes of thought and action that produced the challenges accompanying it. Here I refer to, among others things, the instrumental rationality that has come to characterise social practices such as education, captured in, for example, the notion of education for sustainable development (ESD). It is with this in mind that I open up ways of rethinking the constructs sustainability and curriculum so as to register possibilities of liberating these from the shackles of instrumental rationality.

Rethinking Sustainability

Brown (2015) argues that the contemporary idea of sustainability is of societal scope and not applied to only one sector. He writes: 'Its claims are not merely utilitarian calculations of cost and benefit, but state the kind of society towards which we should aspire' (2015:7). This is

evidenced by the recently formulated 17 sustainable development goals of the United Nations that provide an *a priori* image of a future global society.

Sustainability/unsustainability has been the subject of much contestation. There are difficulties with the term and some of the criticisms levelled against sustainability are: it has internal contradictions; it manifests epistemological difficulties; it reinforces a problematic anthropocentric stance; it has great appeal as a political slogan; it is a euphemism for unbridled economic growth; it is too fuzzy a term to convey anything useful; and it does not take into consideration the asymmetrical relation between present and future generations (for detail see Bonnett, 1999; Bonnett, 2002; Le Grange, 2008; Stables & Scott, 2002). Irwin (2008) also notes that sustainability has been taken up in neoliberal discourses and permeates multinational corporations, pan-global organisations, national governments, education policy, institutions and curriculum. In a similar vein, Parr (2009) suggests that sustainability has been hijacked by the military, government and the corporate world. Furthermore, Le Grange (2013) argues that the notion of 'needs' reflected in the popular definition of sustainable development should be understood in the context of the emergence of 'needs' as a political discourse in late capitalist society – that 'needs' is a political instrument. Brown (2015:2), however, argues that sustainability's radical potential became hegemonised by the narrow concept of sustainable development, but that the latter is being eroded so that its future re-emergence could be a more powerful political concept. At this juncture, it is apt for me to turn to a discussion that opens up ways in which sustainability might be rethought. I shall focus on three alternative readings of sustainability: Parr's (2009) notion of 'sustainability culture'; Le Grange's (2011) 'sustainability as rhizome'; and Brown's (2015) idea of 'sustainability as empty signifier'.

In her book *Hijacking Sustainability*, Adrian Parr (2009) suggests that there is an alternative conception of sustainability to its co-opted form by governments, the military and the corporate world. She notes the need to distinguish between culture that functions as a point of disequilibrium and insurgency, and the mediated form of culture that functions as a point of control and order. The former, she suggests, is used to enhance life and the latter to limit life. The unmediated (or less mediated) culture Parr calls 'sustainability culture'. The power of sustainability culture is *potentia* (the power of the multitude) and its presence curbs the power of the state, the military and the corporate world, that is, *postestas* (the power of the sovereign). Sustainability culture taps into the creative and productive energies of *potentia*, inviting us 'to imagine and design alternatives to how a culture is produced, disseminated, and consumed' (Parr, 2009:165). Moreover, it is optimistic insofar as it encourages us to work for a future that is based on the interest of the common good rather than on maximising profits. Sustainability culture aspires to create processes that affirm the vitality and dynamic materialism of life as these imbue life – this vital materiality is the ontological energy shared by all of life (2009:165). It (re) generates life by tapping into what is immanent to *potentia*, producing what is unimaginable but within the limits set by life itself. As Parr (2009:165) writes: 'Yes life has limits – Earth's metabolism can gulp down only so much of our waste, and Earth can recycle only a finite amount of the toxins industry spews into the atmosphere.' In short, Parr argues that the co-opted or hegemonised conceptions of sustainability (*potestas*) could be counteracted by a sustainability culture that is grassroots – a movement that harnesses the creative potential of society (*potentia*).

Le Grange (2011) argues that sustainability could be a carrier of alternative possibilities if viewed rhizomatically instead of arborescently. A rhizomatic view of sustainability (education) decentres it, producing a distributed knowledge system that opens up pathways for including marginalised knowledges, including indigenous ones. Understood in this way, sustainability education connects the ideas, tools and skills of all participants involved (community members, academics/teachers and students) in multiple ways to produce 'new' knowledge in 'new' knowledge spaces. Deleuze and Guattari (1987) remind us that the rhizome has no points or positions, such as those found in a structure, tree or root – there are only lines. Lines enable proliferation in all directions to form assemblages. Sustainability (education) therefore could be understood as an assemblage, meaning that it increases its dimensions of multiplicity, and necessarily changes its nature as it expands its connections. Viewed in this way, sustainability is rescued from the normalising, homogenising and domesticating effects produced by an arborescent view of the term. Put simply, sustainability (education) as a rhizome connects in multiple ways with people and the more-than-human world, and learning involves understanding the interconnectedness of humans and humans, and humans and the more-than-human-world and how new connections might be generated. Rhizomes create new forms of cooperation, new knowledge spaces and unlikely fidelities.

Brown (2015) draws on the work of Ernesto Laclau and argues that sustainability might be viewed as an 'empty signifier' and that as an empty signifier it holds potential for radical politics. For Laclau (1996) an empty signifier is a 'signifier without a signified'. It is not a word without meaning but concerns the possibility of signifying the limits of signification. Brown (2015:3) writes:

> This 'limit' refers not to a neutral, empirical boundary, as such a boundary could itself be signified and thus be incorporated into the signifying system. The limit in question is rather what has been excluded from the discourse. It is a 'radical' limit … Since what is outside such a limit cannot be signified except through inclusion into the signification, the only way in which this limit can 'appear' is through the interruption or failure of the very process of signification.

Brown (2015:10) argues that empty signifiers stand in the gap when there are mutually incompatible discourses – discourses which are antagonistic. Discourses are antagonistic when they cannot be incorporated within a particular system of signification. Antagonistic relations result when there is something that the discursive system is unable to hold and leads to the dislocation of the identity of those who constitute the relation. In the context of our discussion, when dislocation occurs it brings into sharp focus the untenable futures the discourse is producing. For example, the strong focus on conservation/environmentalism at the conference on Human Development held in Stockholm in 1972 was challenged by members of the developing world who argued for the need for development to take place in their countries to overcome poverty and related concerns. Likewise, undesirable futures that would result from the continued use of fossils fuels (forming part of the economic rationalist discourse) have been brought into sharp focus by the climate change discourse. Put simply, what Brown is

arguing is that when sustainability is hegemonised into a narrow discourse such as sustainable development, the potential for discourses that are antagonistic to it is always there. Viewing sustainability as an empty signifier therefore makes a radical politics on sustainability possible.

For example, the dominant discourse of sustainable development is untenable because it relies on significant exclusions – captured by a rhizome of disparate social groups/movements: feminists, upstanding citizens, vegans, anarchists, communists, right-wing groups, environmentalists, to name a few. Brown (2015:17) argues that 'as an empty signifier, sustainability allows these multiple ruptural points to be condensed in a generalised concern for the future'. Moreover, sustainability ceases to be an empty signifier when an ecologically and socially harmonised future is articulated, including all creative attempts to realise it.

Two points about the discussion on rethinking sustainability: firstly, in its territorialised forms (including its co-optation), sustainability has colonising, homogenising and domesticating effects; secondly, it can be a carrier of alternative ways of being and becoming – it can open up multiple pathways for becoming – it has the potential for radical political action – it can be harnessed as a grassroots culture that does not simply leave it to the market or governments, to sort out. However, to a lesser (Parr, 2009; Le Grange, 2011) or greater (Brown, 2015) degree, the approaches to rethinking sustainability reflect a correlationist stance, that sustainability (sustainable futures) is a correlate of human thought and therefore anthropocentric. Hence, there is a need to explore alternative pathways for sustainability. We can't eradicate human thought, but instead of reducing the world to human thought, human thought needs to be bent by the earth. This means that humans should not only inhabit the Earth but let the Earth inhabit them. Furthermore, the arrogant 'I' of Descartes' *cogito*, should become an embodied, embedded, extended and enacted 'i'. In this regard, much inspiration could be gained from indigenous peoples' ways of being–knowing, where ethics involves a commitment to the entire cosmos (see Le Grange, 2012a; 2012b) and there is no distinction between being (ontology) and knowing (epistemology). Moreover, it is noteworthy that in the world of many indigenous peoples, the word sustainability does not exist – it is not something that needs to be strived for and that exists outside of being, but encapsulates everything indigenous peoples do (being and action).

These are tentative points for further exploration. What the discussion thus far shows is that the potential for lines of escape from hegemonised discourses is always present – that sustainability can be freed from the shackles of instrumental rationality. More can be said about this, but let us now shift the discussion to curriculum because, in the western(ised) world, education occurs in institutions, and ideas on sustainability form part of the curricula of such institutions.

Rethinking Curriculum: Aoki's Story of Bobby Shew

In this section I shall explore how we might rethink curriculum so as to overcome the instrumentalist logic of dominant approaches to curriculum. This discussion can also serve to provide insights into how the instrumentalist logic of education for sustainability might be overcome. In my exploration I draw on insights from Japanese-Canadian curriculum scholar,

the late Ted Aoki. Much of Aoki's intellectual endeavours focused on questioning dominant views of curriculum and opening up new ways of thinking about curriculum. He argued that in our conventionalised world when the word, curriculum is invoked, it conjures up images of a master curriculum, that he called the *curriculum-as-plan* (Aoki 1999:180). He suggested that another meaning of curriculum needs to be legitimated, which is called the *curriculum-as-lived*, by teachers and learners.

In the winter of 1981 Ted Aoki, who was the then head of the department of secondary education at the University of Alberta, learned that Bobby Shew (a jazz trumpeter) was invited to be a visiting scholar to the music department across campus. He decided to invite Bobby Shew to speak at a staff and student seminar at his department. There were two questions that Aoki asked Bobby Shew to speak to, sing to or play to: 'When does an instrument cease to be an instrument?' and 'What is improvisation?' (Aoki, in Pinar & Irwin, 2004). Why did Aoki ask Shew these questions? For Aoki:

> The field of curriculum has come under sway of discourse that is replete with performative words such as goals and objectives and products, achievement and assessment – words reflective of instrumentalism… (E)ducation is under hold of technological rationality … we have become so production oriented that the ends–means paradigm, *a* way to do, has become *the* way of doing. (2004:368)

What were Bobby Shew's responses to these questions: To the question of when an instrument ceases to be an instrument, Shew said: 'When music to be lived calls for transformation of instrument and music into that which is bodily lived' – 'The trumpet, music, and body must become as one in a living wholeness' (2004:368). To the question of what it is to improvise, he said that when improvising with fellow musicians they do not only respond to each other but also to whatever calls upon them in that situational moment and that no two situational moments like life itself is the same. In his words: 'Exact repetition, thank God, is an impossibility' (2004:368).

Aoki (2004:369) argues that we need to rethink the instrumental language in curriculum talk, captured in expressions such as 'curriculum development', 'curriculum implementation', 'curriculum integration' and curriculum piloting'. Instead he suggests that we should develop a new language that is non-instrumental, with expressions such as 'curriculum improvisation' – and I would add 'curriculum experimentation'. Aoki argues that the notion of improvisation reverberates within us and animates us – curriculum improvisation 'provokes in us a vitalizing possibility that causes our whole body to beat in a new and different rhythm' (2004:369). Curriculum implementation demands of teachers to be loyal to a curriculum and is indifferent to their lives, as well as the lives of learners and the context in which they find themselves. In contrast, when teachers are improvisers, they are sensitive to both their own and learners' changing lives and experiences and the fluidity of the contexts in which they find themselves. Le Grange (2014) argues that in the case of curriculum implementation, the role of the teacher is akin to that of the conductor of a classical orchestra where the composer of the music (the outside expert/policy-maker) transcends the performance and although there is some

interpretation of the musical piece, the conductor (teacher) has to ensure that the members of the orchestra (learners) play each note correctly. A deviation from the musical sheet (the prescribed curriculum or policy) is viewed as a mistake' (Le Grange, 2014). Whereas in the case of curriculum improvisation, pedagogy is akin to improvisational jazz where every musician (student) is a composer – where a 'mistake' could be a line of flight that produces something new. In the classroom situation, although the [teacher] may be more experienced and 'knowledgeable', the educative performance, as in the case with improvisational jazz, is a meshwork of interactions that does not enable one to identify actions of teacher/lecturer that causes learning.

Performative words – such as aims and objectives, outcomes, curriculum development, curriculum implementation, policy-practice gap, standardised tests, sequencing and pacing, etc. – are part of instrumentalist language. It is the effects of instrumental rationality that are particularly dangerous. The effects of instrumental rationality are colonising, homogenising, dehumanising, domesticating, and so forth (for detail, see Le Grange, 2014, 2016). Curriculum becomes moribund and pedagogy banal. Pedagogy becomes cold and heartless and the Earth becomes a stage on which pedagogy is performed. Furthermore, multiple pathways (that exist prior to human thought) for transforming the world and for creating alternative futures are reduced to a single way of knowing, being and becoming. The upshot is that no newness is brought into the world. As with curriculum, it is a commitment to instrumental rationality that has resulted in sustainability education being hegemonised into a narrow discourse of education for sustainable development. The effect of this is unsurprising. A recent analysis of four Decade for Education for Sustainable Development (DESD) products, Huckle & Wals (2015:502) conclude that the DESD has been 'business as usual' as far as challenging neoliberalism and in promoting global education for sustainability citizenship (GESC). In a similar vein, the achievement of the Millennium Development Goals has been questioned and words such as failure have been used to describe the lack of achievement of targets of some of the goals (Saith, 2006; Easterly, 2009). This will inevitably be no different with respect to the SDGs of the United Nations.

Aoki's thoughts into the debilitating effects of an instrumental language in curriculum and his suggestion that new words need to be created to overcome such a language, provide useful insights into how we might (re)think sustainability education and in particular the narrow discourse of ESD; reflected on a global scale through the DESD on a national level through national curriculum frameworks and at a local level when teachers frame environmental/ sustainability concerns in terms such aims, objectives and goals. Aoki's insights are also a cautionary note to the field of environmental education regarding words and language used, including the framing of the call for papers of this special issue of SAJEE that speaks about UNESCO's goals for 2030 and ESD. Therefore, we need to create new words/figurations that will bring newness into the world and create alternative futures – new words such as curriculum improvisation and the words discussed earlier with regard to rethinking sustainability such as sustainability culture, sustainability as rhizome and sustainability as an empty signifier. However, as pointed out, the words on sustainability might still have strong anthropocentric leanings and I shall argue, so too Aoki's thoughts.

Bobby Shew's response to Aoki's question, 'when does an instrument cease to be an instrument', is worth revisiting. I specifically refer to Shew's response, 'The trumpet, music, and body must become as one in a living wholeness.' Shew is saying that an instrument ceases to be an instrument when trumpet, music and body become imperceptible. But, I wish to extend this idea beyond the human and the instruments or artefacts he/she produces to a post-anthropocentric idea that includes oneness with the Earth. The subject of sustainability education that is post-anthropocentric is not an atomised individual but is ecological; embedded in the material flows of the Earth/Cosmos, constitutive of these flows, making the subject imperceptible. Pedagogies that are produced in the classroom are not performed on the Earth but bent by the Earth – teacher and student/learner become imperceptible and represent a microcosm of the living wholeness of the Earth/Cosmos. Aoki's notion of improvisation could also be expanded to not only be concerned with the human that reverberates from within and is animated, but to include the vibrations of the Earth, its flows, rhythms and creative intensities. We need to create new concepts that open up opportunities for experimentation. It is in experimentation with the real that we expand our powers to enhance life in a context where we are presented with challenges of a post-human condition.

Aoki (in Pinar and Irwin, 2004:373) argued that the instrumental language in curriculum privileges the visual (*videre*) because this approach to curriculum is based on the natural sciences, where observation is privileged. Aoki argues for the importance of hearing/listening (*sonare*) – that we need to hear the words of the instrumental language in curriculum; curriculum development, curriculum implementation, curriculum integration, curriculum piloting so that these words and the instrumental language can be transcended. Moreover, Aoki suggests what we might listen to by quoting Heidegger, 'We have ears because we are hearkening, and by way of this heedfulness, we are allowed to listen to the Song of the Earth' (in Pinar and Irwin, 2004:375). But, I would add that we also need to feel (*sentire*) the earth – its material flows, its creative intensities.

Conclusion

The post-human predicament invites a questioning of social norms, an interrogation of existing modes of thinking and doing. The historical moment in which we find ourselves comes with uncertainty and complexity and there can be no predetermined pathway for/to the future. This historical moment invites experimentation, improvisation, re-imaginings and sensibilities attuned to the sounds of the Earth, its heartbeat and its affects. Instrumental rationality dissipates when the self (the arrogant I) becomes imperceptible – when subjectivity becomes ecological rather than atomised. Sustainability becomes about acting positively in the world through extending our powers to enhance life. Braidotti (2006:259) avers that 'a positive ethics of sustainability is … an act of faith in our capacity to make a difference and as such it is an expression of generosity and love of the world. It is also a plea, an open question, a reaching out, or invitation to the dance ('let's do it').'

Note on the Contributor

Dr Lesley le Grange is a distinguished professor in the Faculty of Education at Stellenbosch University, South Africa. Lesley teaches and researches in the fields of environmental education, research methodology, science education, curriculum and assessment. Email: llg@sun.ac.za

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Enhancing Life Sciences Teachers' Biodiversity Knowledge
A Professional Learning Community Approach

Sirkka A.N. Tshiningayamwe, Environmental Learning and Research Centre, Rhodes University, South Africa

Abstract

In the last two decades, South Africa has made efforts to integrate biodiversity content in its Life Sciences curriculum; however its implementation lacks systemic coherence. This is due to ineffective professional development approaches. This paper provides insights into how Life Sciences teachers in the Eastern Cape can be supported through professional learning communities (PLCs) as a potential approach to enhancing their biodiversity knowledge. PLCs are communities that provide the setting and necessary support for groups of classroom teachers to participate collectively in determining their own developmental trajectories, and to set up activities that will drive their development. The case study presented in this paper is part of a broader qualitative PhD study which explored the functionings and conversion factors in biodiversity teacher PLCs in South Africa. Drawing on teachers' and facilitators' experiences and the observation of the PLC approaches, the capability approach was used to analyse the functionings and conversion factors that enhance teachers' biodiversity knowledge. The paper highlights that for PLCs to be effective approaches for professional development, they need to be aligned to teachers' valued functionings. It also reveals that different conversion factors enable teachers' achievements of valued functionings in the PLC. The paper aims to contribute to wider policies on capacity building for teachers.

Introduction and Context

South Africa is rated as one of the countries with the most biological diversity in the world (DEA, 2014). The country is home to about 95 000 known species (2014). However, an assessment of biodiversity and ecosystems in 2011 found that, compared to other southern African countries, South Africa has a high number of threatened species (Driver *et al.*, 2012). Approximately 12 million South Africans depend on the natural environment to meet their needs (2012). This results in overharvesting of biological resources – one of the main causes of biodiversity loss in the country (DEA, 2014). Biodiversity loss is not only a South African crisis, it is a global phenomenon (UNESCO, 2014). This report highlights that global biodiversity, which plays an important role in maintaining and enhancing the well-being of over seven billion people in the world, continues to decline. The realisation of biodiversity conservation as a global concern has resulted in various international conventions, policies, and legislations (Shava & Schudel, 2013). South Africa is a signatory to these international conventions and has national policies aimed at conserving biodiversity such as this National Environmental Management Biodiversity Act. This act introduces a legal framework for governing sustainable

development in South Africa and includes a clause for all training and education programmes to integrate education for sustainable development (ESD) (Republic of South Africa, 1998). Thus, like many other countries in the world, South Africa has included biodiversity components in its Curriculum Assessment Policy Statement (CAPS).

The Life Sciences subject covers a considerable amount of biodiversity-related elements (DBE, 2011). However, due to a lack of teachers' subject knowledge, poor pedagogy, and assessment practice, its implementation lacks systemic coherence (Songqwaru, 2012). Professional development efforts have been made to support teachers with the implementation of environmental learning, such as biodiversity content in the curriculum; however, very little has been achieved in ensuring that environmental issues such as loss of biodiversity are consistently and coherently implemented in the school curriculum (Lotz-Sisitka, 2011). Many professional development initiatives have been described as once-off trainings, often with little relevance to the needs of teachers (DBE, 2015). For professional development programmes to be successful, they have to be personally meaningful to the participating teachers, and should be aligned to their needs (Darling-Hammond, 2008). In response to this and in line with international trends, South Africa calls for collaborative learning as a main strategy to support the ongoing professional learning and development of teachers through support systems that promote the establishment of PLCs (DHET & DBE, 2011). PLCs aim to move teachers from being subjects in their learning spaces to becoming educational change agents (2011). In South Africa, PLCs are relatively new policy concepts; thus, limited research exists on how PLC approaches contribute to teachers' professional development. In line with the South African policy landscape, the Fundisa for Change national teacher education programme aims to pilot and develop the concept of professional learning communities (PLCs) within the context of environmental learning (Lotz-Sisitka, 2011). The study focusing on how professional development initiatives can be structured and supported to expand teachers' biodiversity knowledge was positioned within the Fundisa for Change programme. This paper therefore speaks to the research gap by exploring how PLC approaches can enhance teachers' capability for teaching biodiversity content in the curriculum. This paper is framed by the following two questions:

- What are teachers' valued functionings in teaching biodiversity?
- What conversion factors in PLCs enable and/or constrain teachers' achievement of their valued functionings in teaching biodiversity?

This paper aims to contribute a) to the South African policy landscape on teacher professional development, and related global policies such as the Global Action Programme (UNESCO, 2014), and b) towards transforming and strengthening teachers' practices.

Professional Learning Communities

PLCs are 'communities that provide the setting and necessary support for groups of classroom teachers to participate collectively in determining their own developmental trajectories, and to set up activities that will drive their development' (DHET & DBE, 2011:14). Examples of PLCs

are: teacher learning communities, teacher networks, critical friend groups, study groups and professional networks. PLCs are grounded in adult learning theories aligned with socio-cultural learning, grounded in the work of Vygotsky (1978). Through Vygotsky's theories, the idea of scaffolding was identified by Bruner, which implies that people learn at a much higher level when support for their learning gap is provided through peer interaction, or the contribution of a more knowledgeable other (Vygotsky, 1978). In the case of PLCs, this suggests that teachers must understand their own acquisition of biodiversity knowledge, and its relationship within the social context, in order to enhance their knowledge. This requires a forum for teachers to construct biodiversity knowledge through a continuous cycle of learning rooted in reflection, social collegial interaction, professional dialogue, and all processes that can provide scaffolding for improved knowledge for teaching (Stoll *et al.*, 2006). Here the focus is on a course-initiated PLC and explores the potential of this approach to enhancing teachers' biodiversity knowledge in the Eastern Cape.

The Eastern Cape Context

The Eastern Cape is situated in the south-eastern part of South Africa. Based on the last census, an estimated 6.75 million people lived in the province (ECSECC, 2015). The Eastern Cape is considered the poorest province in South Africa and faces significant social challenges, including: poverty, income inequality, food insecurity, and unemployment (2015).

The Eastern Cape produces the poorest grade 12 results every year (ECSECC, 2015); with political, social and economic factors compounding the poor performance rates of learners in the province. This is due to the lack of access to decent learning facilities, large class sizes, and a lack of funds (Ncanywa, 2014), among other features. Language in schools is another significant barrier to effective teaching and learning (Murtin, 2013). There are 23 school districts demarcated across the province, grouped into three geographically demarcated clusters. Clusters A and B are 99.9% rural and consist of schools situated in villages from the former apartheid era of the Transkei and the Ciskei (Ncanywa, 2014). Most of these schools are underdeveloped, with poor infrastructure. Cluster C has a number of former model C (semi-private) and private schools found in each district (Ncanywa, 2014). The sample group is from cluster B.

The Eastern Cape Biodiversity Context

Environmental threats within the region include land degradation, soil erosion and high pressure on groundwater (Hamann & Tuinder, 2012). The main use of water is irrigation, which accounts for almost two-thirds of water resources required in the province. Overall, it has more estuaries than any other South African province, with river ecosystems under considerable pressure due to high demands for water resources (2012). Most of these estuaries are described as healthy and are important nursery and feeding areas for a wide range of fauna and flora (DEA, 2014). In terms of biodiversity, the Eastern Cape has a higher biome diversity than any other province in South Africa, including all South African biomes except the desert (Hamann & Tuinder, 2012), as well as a number of endangered ecosystems. A total of 316 threatened plant

species are found in the province, which is also home to four endemic freshwater fish species, eight threatened marine fish species, six threatened frog species (four of which are endemic) and 19 threatened reptile species (18 of which are endemic) (2012).

Theoretical Framework

Functionings and capabilities are among the core concepts of the capability approach developed by Amartya Sen. A functioning is 'the various things a person may value doing or being' (Sen, 1999:75) which are the practical realisation of one's chosen way of life. Capabilities are 'the alternative combination of functionings that are feasible for [a person] to achieve; they are the substantive freedom "a person has to lead the kind of life he or she has reason to value"' (Sen, 1999:87). While capabilities and functionings are inextricably linked, they remain distinct (1999:87). Capabilities represent a possibility instead of an actuality (1999:87). Of interest to this paper was the understanding of what Life Sciences teachers' valued functionings were in relation to biodiversity teaching. Life Sciences teachers might have similar valued functionings, but different capabilities, and thus require different resources to achieve them (Sen, 1999). Also central to the capability approach is the concept of conversion factors (Robeyns, 2005). Conversion factors are those which can allow teachers in PLCs to convert resources to new functionings (Robeyns, 2005). She distinguished between three sources of conversion factors that can constrain or enable people's capabilities. These are:

- *Personal conversion factors*: those determined by one's mental and physical aspect. They are internal to the individual, such as intelligence.
- *Social conversion factors:* those determined by the society in which one lives, such as curriculum policies.
- *Environmental conversion factors*: those determined by or emerging from the physical environment in which a person lives. These can be aspects of one's geographical location, such as proximity to an ocean.

Robeyns (2005) further noted that personal, social and environmental conversion factors are interrelated. Therefore, the capability of individual Life Sciences teachers in the PLC is likely to be dependent on these interrelated conversion factors. The context in which the PLC activities happen, and the teachers' relationships in the PLC may have the potential to expand or constrain individual teachers' biodiversity knowledge (Robeyns, 2005). It is thus not enough to know what functionings Life Sciences teachers can or cannot achieve; we also need to know the circumstances in which PLCs are situated.

Research Design

The research was a qualitative case study, stressing the socially constructed nature of empirical experiences, the intimate relationship between the researcher and what is studied, and the situational constraints that shape inquiry (Denzin & Lincoln, 2011). Case study methodologies are significant for learning about environmental learning (Lotz–Sisitka & Raven, 2004) as

they enable research about environmental issues in contexts including biodiversity. The PLC activities happened in two contact sessions (three days a session). Four teachers (T1, T3, T5, T6) had five years of teaching experience or more. Both sessions were attended by the same ten Life Sciences teachers and three facilitators. The teachers were qualified to teach Life Sciences. Except for T2, they all had one or more qualifications in the field of education. The qualifications varied from a Senior Secondary Teaching Diploma in Education to a Bachelor of Education Honours degree. Data was generated through six semi-structured interviews with teachers (given codes T1-T6), two facilitators (given codes F1 & F2), and observations of the contact sessions. Document analysis was done on the Life Sciences CAPS documents, which served as primary data sources (Harland, 2014). The data generated was analysed using the capability approach concepts of capabilities, functionings and conversion factors described above. Careful attention was given to ethical issues that confronted the researcher, including policies regarding informed consent, confidentiality and anonymity (Harland, 2014).

Research Findings

At the beginning of the PLC activities, the teachers' valued functionings in relation to the teaching of biodiversity were explored. In line with the PLC objectives, teachers indicated that their core functionings were to expand their biodiversity knowledge, improve their teaching and strengthen assessment practice.

Biodiversity knowledge
An analysis of the Life Sciences curriculum shows that biodiversity knowledge mainly follows two knowledge strands: (a) diversity, change and continuity, and (b) environmental studies (DBE, 2011). Those include concepts such as biodiversity of micro-organisms, plants and animals; and pollution ecology and human impacts on the environment. Teachers valued being knowledgeable about biodiversity. Two teachers noted the following as potential goals: 'To have more information about biodiversity and to know why it is important to conserve species' (T2) and 'To gain more knowledge on how to teach learners on the ecosystems' (T6). Emerging from the observations, teachers lacked in-depth understanding on the core concepts of biodiversity, such as: biomes, taxonomic classification, ecological niche, human impact on biodiversity and the three levels of biodiversity (species diversity, genetic diversity and ecological diversity). Teachers were unable to fully explain some of the concepts. For example, T3 defined marine species as 'species found in water'. None of the teachers knew which biomes were found in their context. In response, the PLC activities were structured to explore the core concepts of biodiversity. For example, the concept of marine species was expanded to include species that are not found in water but rely on species found in the water. Another example was that maps of biomes in South Africa were engaged with, exposing teachers to the different biomes. Teachers maintained that biodiversity content is challenging, noting: 'I did not know that biodiversity was challenging. I only noticed that after we have dealt with it' (T4), and 'Biodiversity is challenging. A lot of teachers are not knowledgeable on it' (T5).

In addition to engaging with key concepts, the PLC activities also explored the roles of biodiversity, and drivers and responses to biodiversity loss. Among the drivers of biodiversity loss explored were habitat change, pollution, invasive species, overexploitation and climate change. Some of the emerging responses to biodiversity loss discussed included: environmental education, indigenous conservation species, policy, legislation and international environmental conventions.

Pedagogical practices

The curriculum document stipulates that teachers should be able to conduct practical and fieldwork activities (DBE, 2011:33). For example, under the topic of 'biosphere and ecosystems', teachers are expected to 'choose one ecosystem close to the school within a local biome for special study' (DBE, 2011:33). Teachers' weak pedagogical knowledge was confirmed by F2 who noted:

> The problem is not only content but also methodology of teaching. Most teachers don't use exciting teaching methodologies such as experiential learning, field learning, outside learning. Even simulations, in most cases they are quite artificial in the sense that the examples used by teachers do not really speak to the real world.

Among other pedagogical practices, teachers therefore sought to enhance their practical knowledge for conducting practical activities and fieldwork. They revealed that pre-service training, however, did not sufficiently capacitate them on how to conduct practical activities, as T2 said:

> It is difficult to do practicals; I don't know how to do it. At university we were only taught theory and did not do it in practice. You don't know whether what you are doing is right, you don't have enough resources. At least if I can get support on how to do practicals, like how you are supposed to present and reflect on the topic.

To enable teachers to achieve their valued functionings, the PLC activities examined a range of pedagogical approaches appropriate to biodiversity concepts and learning context. Pedagogical approaches (with examples of methods) were discussed under the following categories (Rosenberg, O' Donoghue & Olvitt, 2008):

- *Investigative methods:* participatory methods, fieldwork, case studies;
- *Deliberative methods:* social learning methods, critical media analysis, scenarios;
- *Learning-by-doing methods:* projects and practicals, community problem-solving;
- *Experiential methods:* interpretive trails, role-play, values clarification; and
- *Information transfer methods:* presentations, guided questioning, excursions.

Different pedagogical approaches were discussed and modelled. For example, the scenario planning method was used to demonstrate a reduction in mussel species; role-play was used to explain the concept of human impacts on biodiversity; and field activities were conducted to

expand teachers' capabilities for conducting fieldwork in the marine ecosystems. As part of the fieldwork activity, teachers had to identify marine species, and use them to construct taxonomic keys and food chains.

Assessment practices

The Life Sciences curriculum describes three different types of assessments: tests, examinations and project-based assessments; with all assessments structured according to Bloom's taxonomy (DBE, 2011). The weighting of cognitive demands are shown in Table 1.

Table 1. Weighting of cognitive demands of assessment tasks

	Knowing science	Understanding science	Applying scientific knowledge	Evaluating, analysing and synthesising scientific knowledge
%	40%	25%	20%	15%

Source: DBE (2011)

The Life Sciences curriculum clearly outlines the different topics to be covered in the summative assessments and their marks allocation; for example, the topic of biodiversity and classification is allocated 7%, and human impact accounts for 17%. Despite these curriculum stipulations, teachers were not clear about which types of assessments would best cover biodiversity concepts. Therefore, in the PLC, different assessment practices were explored. The focus was mainly on assessment tasks that promote higher-order thinking and problem-solving skills as teachers lacked the ability to compile questions that promote these skills. This was in line with what teachers valued; for example T1 valued 'learning how to assess learners in different ways that are challenging, not just recalling'. T2 expressed that she did not know how to allocate marks; she revealed:

> Allocation of marks – I don't know it. I just take past question papers, cut and paste with already allocated marks. I don't count that this one falls under knowledge, evaluation, synthesis or comprehension, simply because I do not know how to do it.

The extract above shows that T2 understood the importance of asking different levels of questions, but she lacked the competence to compile assessment tasks aligned with different cognitive levels. She thus valued learning about allocating marks to enhance her ability to design different levels of questions. F1 supported the teachers' views, as he said:

> Teachers cannot assess. When you look at their developmental tasks that they do in their schools, they are of poor quality. They are not developing learners at all. The types of questions asked in the informal tasks are not a variety of questions that learners expect to see in the formal tasks.

To expand on the PLC teachers' capabilities for assessing biodiversity concepts, assessments *for* learning and assessments *of* learning were discussed. Bloom's taxonomy was used to unpack

the cognitive levels to be considered in assessments of knowledge, comprehension, application, analysis, synthesis and evaluation. Focusing on assessment, an excursion to the mangrove forest was conducted. As part of the excursion, teachers did an activity (Figure 1) in three groups, in which they had to answer questions, allocate marks, and state and justify the cognitive levels of the questions.

Figure 1: Activity on assessment

1. Using the field guide on mangrove, list the species found in the mangrove ecosystem.
2. Giving examples from (1), explain why those species are found in that ecosystems.
3. Using the information in (1), draw a food web of the mangrove ecosystem species.
4. Identify any evidence of human activities in the mangrove ecosystem.
5. Discuss any human impact on the ecosystem.
6. Suggest ways on what can be done to protect mangrove swamps and their inhabitants.
7. Using information in (1), construct a dichotomous key for species identified.

Teachers answered the questions but struggled to allocate marks. Table 2 shows the marks allocated by teacher groups.

Table 2: Marks allocated for the assessment activity done

Question	Group 1	Group 2	Group 3
1	3	4	4
2	2	2	4
3	2	3	7
4	2	1	5
5	5	3	5
6	5	3	4
7	6	6	6
Total	25	22	35

Discussions took place on how and why different marks were allocated by different groups. Emerging from all the groups was that the marks were allocated depending on the amount of time, thinking and information required to answer a specific question. For example, all groups agreed that question (3) required understanding and application. Similarly, all the groups gave more marks to question (7) because it is a synthesis question and required higher-order thinking.

Conversion factors in professional learning communities
At the end of the PLC activities, teachers indicated that they achieved their valued functioning. They noted that, in the PLC, there were conversion factors that enabled and/or constrained them to achieve their valued functionings.

Teachers' experiences and qualifications

The difference in qualifications and experiences allowed teachers to learn from each other. The teachers who had fewer years of teaching experience acknowledged their lack of experience as a constraint to their full participation in the PLC. For example, T2 had one year of teaching experience, and she expressed:

> I am new in teaching. Some of the things, I have never heard about them. So I didn't know how to deal with them. There are difficult concepts in Life Sciences that it becomes difficult to present when you don't understand them. So there were colleagues helping or showing me what the concepts mean and how to teach them.

Irrespective of individual differences, the PLC was structured so that all teachers' opinions were valued and respected, as F2 noted:

> There were definitely some who were battling. But it helps when people are feeling enabled to say 'I do not understand.' They were able to express themselves. It could be because of the community of practice. I did hear one of the teachers saying 'we all participated'. I tried to make sure that we don't have dominance.

Effective facilitation skills

There were three knowledgeable and experienced facilitators in the PLC. This was confirmed by T4 who, for example, noted 'the facilitator helped in explaining what "assessment" is and the different forms of assessment, she emphasised that knowledge is not the only thing that learners need to acquire, this will have an impact on my teaching'. The different facilitators were an enabling factor as they brought in different expertise. Good facilitation was thus a personal conversion factor that enabled teachers to achieve their valued functionings.

Collaborative learning space

The PLC brought Life Sciences teachers from different schools together. This provided a collaborative learning environment allowing teachers to express their views and engaging in group activities, as T1 noted:

> It was good to interact with others in a controlled environment. We got time to discuss challenging topics, share information and to express ourselves to the facilitators and to our colleagues about how we feel about particular topics, or how they should be taught.

The teachers' participation in the PLC thus enabled them to achieve their valued functionings. This was noted by F1 who said 'the enabler was the freedom that teachers had in terms of participation. They were free to express themselves and that helped them learn better.' Teachers were given opportunities to reflect on their learning. This allowed for further learning.

Site where the PLC activities happen
The PLC activities took place at Donaldwoods near the Dwesa Nature and Marine Reserve. Excursions were conducted to the marine ecosystems. Teachers found excursions to be great enablers to their valued functionings, as T4 noted: 'The field trips worked for me. I can now differentiate between the different marine ecosystems. I can now differentiate an estuary from mangroves, a sandy shore from sand dunes.' The ocean emerged as a conversion factor that enabled teachers' capabilities for conducting fieldwork and acquiring scientific skills.

Policy context
Curriculum documents were used to inform PLC activities. Teachers had different interpretations of the curriculum and its demands. They were not confident in using the curriculum documents. This was confirmed by F1, who reflected that 'teachers did not understand the CAPS requirements and that was a concern'. Curriculum documents were used for different activities; for example, they were used for conceptual progression and to analyse the assessment and pedagogical practices required for biodiversity-related topics. Using the curriculum documents in the PLC thus enabled the teachers' achievement of their valued functionings. As T3 noted, 'there is progression of knowledge which we did not know. So now if I take a policy document, I will say here there is progression.'

Access to teaching and learning support materials
In the PLC, teachers engaged with different materials that were designed to provide them with access to additional learning support material. Resource materials from local organisations were used to expand teachers' situational knowledge. For example, field guides were used to identify the marine ecosystems and species. Teachers indicated that the teaching and learning support materials used in the PLC enhanced teachers' biodiversity knowledge, pedagogies and assessment practice. T6, for example, said 'the materials provided were very effective, especially during the activity time'. Teachers received teaching and learning support materials to use in their work to enhance teaching and learning, as T5 confirmed: 'we have been given a lot of materials which will assist us as far as our teaching is concerned'.

In addition to the above, teachers mentioned time as the main conversion factor that constrained their in-depth understanding of some of the biodiversity concepts, and pedagogical and assessment practices. This was confirmed by F2 who stated: 'I believe we could have touched more things in details but we were worried about the schedule.' To reconcile this constraint, teachers expressed that either more time could have been provided for the activities, or the PLC activities should be ongoing.

Interpretation and Discussion of the Findings

Biodiversity education is oriented towards socio-ecological change processes and requires learners to engage with local and global biodiversity issues and associated risks (O'Donoghue, 2015). Biodiversity education also calls for assessment practices that will assess learners' high-order thinking skills and problem-solving skills (O'Donoghue, 2015). The challenge for teachers

is to design activities that allow for critical engagement with contested and complex concepts of biodiversity in local contexts. This requires interdisciplinary approaches to teaching and learning (McKeown & Hopkins, 2014). The PLC activities examined the range of teaching methods that are most appropriate to Life Sciences and to the biodiversity concepts and context of learning (i.e. investigative and deliberative methods) (Rosenberg et al., 2008). In Life Sciences, assessments should be designed to cover the different cognitive levels, to cater for a range of abilities of learners (DBE, 2011). Teachers were not clear on what types of assessments would best assess biodiversity concepts (Songqwaru, 2012). Therefore, the PLC activities explored assessment practices that would expand the teachers' capabilities for developing assessment tasks that would would, in turn, expand learners' higher-order thinking skills and promote critical-thinking and problem-solving skills.

Resonating with Cundill et al. (2014), the PLC activities started with an exploration of the teachers' expected outcomes of the learning process. This helped the faciltators to be responsive to teachers' individual valued functionings related to the teaching of biodiversity. The teachers lacked the ability to identify and work with the biodiversity content in the Life Sciences curriculum. This was due to a lack of capacity in teacher education institutions to adequately prepare teachers with sound subject content knowledge for biodiversity teaching (McKeown & Hopkins, 2014). In South Africa, environmental knowledge has been integrated into teacher education programmes such as the environmental education elective in a Bachelor of Education, Honours degree (Lotz-Sisitka, 2011; O'Donoghue, 2015). This is to expand teachers' capabilities to work with environmental and sustainability knowledge (such as biodiversity knowledge) in the school curriculum. These programmes are yet to make an impact on teachers' knowledge. This was demonstrated by the teachers' lack of competence to work with biodiversity concepts. The teachers' valued functionings were aligned to the integrated and applied knowledge required for quality teaching (disciplinary, pedagogical, practical, fundamental and situational) (DHET, 2011). These were core to the PLC activities.

Even though the teachers had similar capability sets, they needed different resources to achieve their same valued functionings (Sen, 1999). In the PLC, there were different personal, social and environmental conversion factors (Robeyns, 2005) that enabled and/or constrained the teachers' valued functionings in teaching biodiversity. The goal of PLCs is for teachers at all stages of their careers to learn from each other (Stoll et al., 2006). Thus, individual experiences were personal conversion factors that enabled teachers to achieve their valued functionings. The PLC activities were structured so that all teachers' opinions were valued and respected. This is defined by the characteristic of inclusive membership (Stoll et al., 2006). Resonating with Huggins, Scheurich and Morgan (2011), external expertise brought in through the facilitators were recognised as personal conversion factors for the achievement of teachers' valued functionings. 'Without the inclusion of outside assistance in PLCs collaboration simply cannot occur due to the lack of sufficient pedagogical and content knowledge within the community' (Huggins et al., 2011:85). As noted by Reddy (2011), teachers have different interpretations of the curriculum and its demands, but working with curriculum documents in the PLC enabled their ability to interpret the curriculum. PLCs do not operate separately from their surrounding entities (Stoll et al., 2006). For example, as noted above, the presence of the

ocean close to the venue were the PLC activities happened was an environmental conversion factor that enabled teachers to expand their capabilities for conducting fieldwork and acquiring the scientific skills required by the Life Sciences curriculum.

In South Africa, there is a lack of quality teaching and learning resources for teachers to teach environmental and sustainability content such as biodiversity (Lotz-Sisitka, 2011). The school textbooks generally present incomplete information. In the PLC, teachers received teaching and learning support materials to enhance their teaching of biodiversity content.

PLCs create a structure for groups and individual professional development through collaboration (Stoll *et al.*, 2006). In this case, it was through sharing ideas and experiences, and engaging in discussions and demonstrations. Teachers acquired new biodiversity knowledge and various skills through social interactions. Vygotsky (1978) noted that learning is a social activity and people learn from their capable peers. The teachers recognised that engaging in professional conversations in the PLC was an enabler to their teaching practice and professionalism (Tshiningayamwe, 2016).

Conclusions and Recommendations

In summary, identifying teachers' valued beings and doings is critical for their own learning. This allows for PLC activities to respond to teachers' individual needs. The PLC structure expanded the teachers' functionings related to their teaching of biodiversity, and agency to be active participants in the PLC. In the PLC, professional development was situative, and outcomes were influenced by personal and group processes. However, for PLCs to be more effective, they need to support teachers' continuous learning by being sustained over time. This requires making more time available for PLC activities, which will allow in-depth engagement with biodiversity knowledge, and pedagogical and assessment practices. This also requires identifying the different functionings.

Notes on the Contributor

Sirkka A.N. Tshiningayamwe is currently a post-doctoral researcher in the Environmental Learning and Research Centre, Rhodes University, exploring how education for sustainable development can be scaled up in teacher education in southern Africa. Email: sirkka.ts@gmail.com

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The Implementation of Environmental Education in Geography (Grades 8–10) in the Caprivi Region, Namibia

Callie Loubser and Patrick Simalumba, Department of Science and Technology Education, University of South Africa, South Africa

Abstract

UNESCO (1995) notes that education should be easily adaptable to sudden shifts in conditions in a world of rapid change since environmental challenges are dynamic. This paper is based on a study carried out in secondary schools in the Caprivi region in Namibia (currently re-named the Zambezi region). The article reports on mixed methods of approach to arrive at an in-depth understanding of the extent to which environmental education is implemented in the curriculum for Geography, specifically for grades 8–10. The data was generated through a self-assessment questionnaire that was sent to all grade 8–10 Geography educators in the region. In addition, interviews were conducted with a sample of educators and a local environmental education officer. Focus group discussions were held with learners from five schools. The findings revealed, among others, that educators had sufficient knowledge and understanding of environmental concepts and issues. However, educators had limited knowledge of environment-related skills and attitudes required, and did not use a variety of teaching approaches or alternative assessment regimes. Educators understand the significance of indigenous knowledge in geographic education, but the research findings also indicate that stakeholders' participation in school environmental education initiatives needs to be strengthened. The article provides recommendations that might improve the implementation of environmental education in schools.

Keywords: Geography, competencies/learning objectives, educational processes, outdoor activities, sustainable development, indigenous knowledge.

Introduction

Since independence in 1990, the Namibian government has given high priority to environmental concerns. Article 95 of the National Constitution (GRN, 1990) refers to the promotion of the people's welfare through sustainable use of resources. Namibia has ratified a number of international agreements concerning the environment, such as the Convention on Climate Change (1992), the Biological Diversity Convention (1992), Agenda 21 (1992), Combating Desertification (1994) and the Basel Convention (1999) (MoET, 2008:7).

Namibia's Vision 2030 (GRN, 2004) and Third National Development Plan of 2008 (NDP3) identified sustainable development as an important national development strategy (GRN, 2008). A National Environmental Education Policy was developed in 1999 with the assistance of the Namibia Environmental Education Network (NEEN) and the Ministry of

Education (MoE). It was stressed that environmental education should be incorporated into the formal education curriculum as a cross–curricular issue. According to the National Curriculum for Basic Education, basic education for the future society should focus on:

> atmospheric, land and water pollution from crop lands or mines, and minimalising pollution from urban and industrial areas, to ensure that farms and natural ecosystems are productive and sustainable socially, economically and ecologically and to ensure that there is high quality, low impact tourism and food security. (MoE, 2010)

The Geography curriculum content, skills and values can contribute significantly towards achieving these objectives.

National research

At a national level, there have been a number of studies on environmental education in Namibian schools since 2000. For example, in his study in Namibian schools, Kanyimba (2002) concluded that environmental education revolves around the integration of knowledge dimensions with a lack of integration of values and attitudes, and to a lesser extent, on the integration of some action and skill dimension of the environment. This was echoed by Haindongo (2014) who found that, in Namibia, subjects such as Biology concentrated on cognitive information about the ecology (education about the environment). She further found that educators lacked professional development support to assist them in teaching environmental education. Investigating how Geography educators were implementing enquiry-based learning through fieldwork, Simasiku (2012) found that, although educators engaged learners in the suggested activities, the findings indicated that educators faced limitations in terms of integrating environmental learning into the Geography curriculum.

Regional research

On a regional level, a study carried out in six primary schools in the Empangeni district in KwaZulu-Natal in South Africa by Makhoba (2009) found that environmental education topics were taught selectively, with preference to narrative teaching methods; while the studies by Monde (2011) and Kalimaposo and Muyela (2014), in selected high schools in Zambia, established that most educators lacked knowledge and resources to support the implementation of environmental education. Mukoni's (2013) research tried to establish if environmental education had any transformative impact on secondary school educators' and learners' behaviour towards the environment, through an assessment of their actions within the school and the community in Zimbabwe. The significant finding of Mukoni's study was that environmental education in schools was mere 'greening' of the curriculum, with a factual approach to environmental education at the expense of action competencies. All these studies exposed deficiencies in the teaching of environmental education in general, hence the significance of a broader perspective for the study, in order to explore how environmental education is implemented in Geography in Namibia.

Conceptual framework

The study is informed by a social constructivist theory of education. The approach to teaching and learning in Namibia is based on a paradigm of learner-centred education (LCE). The starting point for teaching and learning is the fact that the learner brings a wealth of knowledge and social experience to school, which is continually appropriated from the family, the community, and through interaction with the environment. Learning in school must involve, build on, extend and challenge the learner's prior knowledge and experience. Hungerford (2001) notes that the characteristics of constructivism include authentic experience, social interaction, connections to prior knowledge and diverging cultural perspectives. This is supported by Ornstein and Hunkins (2004).

Environmental education in southern Africa is generally espoused to include the social, economic, political and biophysical aspects. Palmer (2003) defines environmental education as an interdisciplinary and holistic form of education geared towards action and change and which promotes the use of participatory learning, learning by doing and action-based methodologies. Waite (2010:112) reminds us that learning outdoors could address broad aims for education such as: physical well-being, social and emotional well-being, and deeper levels of learning. As a subject, Geography tries to understand how people intervene in the world's natural and social processes and in turn, how spaces, places and environments are affected by such interventions. Agenda 21 and the Voice of Eagle recognise the immense contribution that indigenous people, communities and knowledge bases make that can help to achieve a more environmentally sound future. Meanwhile, Huckle and Sterling (1996) caution that educational institutions need to be reoriented towards helping learners learn systemic, future, integrated, problematised and creative values analysis and moral reasoning. It is essential to also note that learning related to the curriculum extends beyond the classrooms the school community and parents also play a role in supporting and extending this learning.

Constructivist epistemology shapes much of the contemporary educational thinking and assessment practice in Namibia. As such, assessment deals with both quantitative and non-quantitative descriptions of events to shows the levels of a learner's improvement. Constructivism emphasises the use of dynamic assessment practices which recognise direct measures of a learner's potential for learning and development in a holistic way. In environmental education, assessment is often centred on awareness, values, attitude change, or the measurement of reduced impact.

Research problem

The research problem lies in the fact that the goals of the National Environmental Education Policy are not being fully realised in Namibia. The main reason for this is that the responsibility for putting an environmental education policy into practice was devolved to regions and schools according to the Education Act of 2001 and the National Curriculum for Basic Education (2010). From 2001 until 2005 Namibia, through the National Institute for Educational Development (NIED), embarked on a comprehensive revision of the curriculum for grades 1–10. Environmental education is one of the cross-curricular issues that were integrated into the curriculum aims, objectives, learning content and assessment of different

subjects. The organisation known as Support Environmental Education in Namibia (SEEN) – supported by DANIDA (the Danish International Development Agency) – helped the MoE with the integration of environmental education processes through professional development, curriculum development, the provision of materials and school-based implementation (in a limited number of pilot schools). It is therefore interesting to find out how schools consolidate this foundation and these experiences to implement environmental education in schools.

Since schools implemented the environmentally integrated curriculum without structured capacity-building programmes for educators at a local level, the researchers sought to determine how schools were implementing the intended curriculum. Although learning support materials were produced and sent to schools, it was important to understand how these materials affected educators' and learners' perceptions of their environment and teaching/learning processes.

It is of interest to learn how schools coordinate environmental education activities at the local level with the support of the approved environmental education policy. It is also relevant to determine the degree to which the national syllabus statements are prescriptive or flexible in allowing educators to integrate aspects of their local environment without compromising the quality of education.

The research purpose

Based on the research problem, the purpose of the research was to determine how schools in the Caprivi region in Namibia implement environmental education in grade 8–10 Geography; with the objective of determining and exploring the extent to which Geography educators have the required knowledge and understanding of environmental education to implement the relevant processes, strategies and assessment in schools through the Geography curriculum (since environmental education is a cross curricular issue in this curriculum).

The paper also assesses:
- The level and nature of environmental skills and attitudes that grade 8-10 learners require, as seen from the educator's perspective;
- The extent to which outdoor activities complement the overall objectives of Geography;
- Geography educators' understanding and perceptions of the significance of indigenous knowledge as a resource in the school curriculum; and
- The extent to which learners understand their environments, issues, learning processes and the presence of school environmental education policies, and how well they are applied.

Methodology

Research design and method

The research design was a mixed-methods research approach, which included aspects of both quantitative and qualitative approaches. The purpose of mixed-methods research is to build on the synergy and strength that exists between quantitative and qualitative research methods in order to understand a phenomenon more fully than is possible using either qualitative or quantitative methods alone (Gay, Mills & Airasian, 2006). Qualitative data can be used to

supplement, validate, explain, illuminate or reinterpret quantitative data gathered from the same subject (Bogdan & Biklen, 2007; Palmer, 2003).

Data collection

In order to gather data, multiple data-collection instruments for educators, learners and the environmental education officer was used. The semi-structured interview questions were designed to encourage participants to describe their experiences in implementing environmental education in the curriculum and in daily life. In addition, educators from all 47 schools in the region offering grade 8–10 Geography completed a self-assessment instrument by giving themselves a rating of one to four for each of the 24 environmental education practice indicators. These indicators focused on knowledge of environmental education (KEL), teaching and learning (TL), learning support materials (LSM), and extracurricular and environmental action (ECEA) programmes. Educators also responded to 32 other environmental indicators on a nominal scale, including environmental education features in schools, school environmental policy issues, information sources, and educators' training needs. Ruane (2005) claims that a good questionnaire can 'stand on its own' without requiring personal contact with respondents. An interview was also held with a local environmental education officer, together with a focus group discussion with learners. Neuman (2006) and LeBeau (1997) affirm the significance of enhancing, validating and triangulating data when various instruments are used; while Gay, Mills and Airasian (2006) attest to the essence of piloting, which was carried out in this study. Lastly, 35 learners' exercise books from five schools were inspected to verify the nature of classroom activities.

Sampling

The research population in this study were Geography grades 8–10 learners and educators, and a local environmental education official. In support, Neuman (2006) and Ruane (2005) highlight that the primary purpose of sampling is to collect specific cases that can clarify and deepen understanding so that the researcher learns about the processes of social life. Five schools participated in the interviews and focus group discussions. Random numbers were assigned to schools and used to select participating schools in each category: urban, peri-urban and rural. This ensured that every school had equal chance to participate. In addition, the self-evaluation instrument/survey questionnaire for educators was sent to all 47 schools in the region with grades 8–10.

Data analysis

Analysis of data involves organising, breaking down and synthesising it, as well as searching for patterns, and discovering new information to tell others (Bogdan & Biklen, 2007; Neuman, 2006). In quantitative research, graphs were used to illustrate the results of the research. Data was analysed inductively, by categorising and organising it into patterns that produce a descriptive and narrative synthesis. In this study, transcripts of interviews and focus group discussions were typed out, and the individual thoughts and ideas of each participant were separately numbered.

The statements of each participant were categorised and coded with respect to the research themes and emerging items. The educators' self-assessment rating questionnaires were analysed

and interpreted by using simple statistical procedures; for example, descriptive statistics such as distribution frequencies. The Statistical Package for the Social Sciences (SPSS) was used to see if there were associations or connections between any of the variables measured by the survey questions.

Ethical considerations

The researchers had a duty to not put participants in a situation where they might be at risk of harm as a result of their participation. Furthermore, Neuman (2006) and Bogdan & Biklen (2007) remind us that the researcher protects the privacy and identity of participants. To that end, the researchers took the following specific steps to ensure that the participants' privacy and rights were protected:

- Informed consent was assured by allowing respondents sufficient knowledge and comprehension of the purposes and intentions of the study;
- The protection of respondents was guaranteed through anonymity; and
- The study's credibility is supported through adherence to the actual audio recordings by either paraphrasing or using actual excerpts from these recordings.

Results and Discussion

Educators' knowledge of environmental education (KEL)

The result of the empirical study (Figure 1) reflected that most educators (61%) were confident about their knowledge of the holistic concept of the environment (KEL3), while 50% of educators indicated that they were confident –39% were very confident – about their knowledge of facts relating to environmental education topics such as population, biodiversity, environmental degradation and risks (KEL1). This was confirmed by educators who identified, in the interviews (qualitative research) the environmental issues they teach from the syllabus such as deforestation, overgrazing, pollution, population and migration. However, quite a high number of educators (36%) indicated that they were unsure about environmental challenges in Namibia (KEL2). This suggests that educators do not use various sources of information to acquaint themselves with environmental challenges at a national level. The majority of educators were confident and very confident (54% and 32% respectively) about their knowledge of the environmental education policy for the formal education sector (KEL4).

Knowledge with understanding about, through, or for the environment enables us to critically evaluate issues and situations in light of the informed understanding (Palmer, 2003; Schnack & Jensen, 1997). Because educators are confident in their knowledge of environmental education (KEL4), it seems as if the curriculum should be flexible enough to include the local context and make provision for educators' initiatives. The national curriculum should not negate educator involvement or focus on national control. There is a danger that the curriculum content will require learners to deliver rather than interpret. This could result in the approval of one set of knowledge and skills, leading many schools to become dependent on a single textbook, with one particular series dominating.

Figure 1. Educators' knowledge about environment
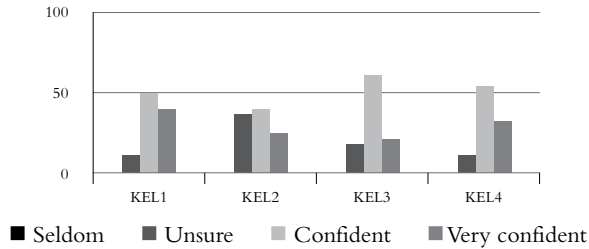
Kel1: Knowledge of factual information

Kel2: Knowledge about environmental challenges in Namibia

Kel3: Knowledge about a holistic conception of the environment

Kel4: Knowledge about the environmental learning policy for the formal education sector

Skills and attitudes (SA)

Skills and attitudes represented by the graph are listed below the graph in Figure 2 which shows that educators felt confident in most of the skills and attitudes included in the questionnaire (ranging from 57–89%); only a few (0–25%) seldom taught these skills or attitudes or were unsure about teaching them. An analysis of interviews conducted with the educators, however, suggested that educators do not understand the kind of skills and attitudes that learners need to acquire in order to contribute to the health of the environment. In most cases, they incorrectly referred to some activities as skills. Only a few reported attempting to mediate activities, which they referred to as skills, such as tree planting and cleaning of the school grounds.

Figure 2. Educators' environmental skills and attitudes
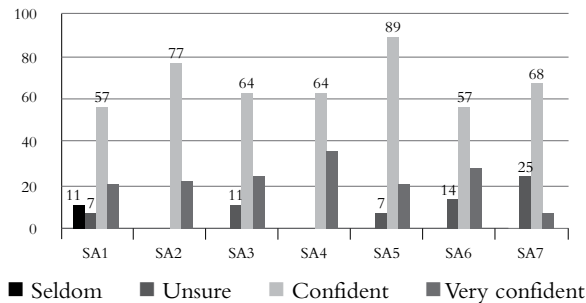
SA1: Communicating the way people's cultural activities affect the environment

SA2: Communicating the way individual people affect the environment

SA3: Identifying their own attitudes and values towards an issue of the environment

SA4: Awareness that there may be more than one way to solve environmental issues

SA5: Skills needed to contribute towards the health of the environment

SA6: Positive attitudes towards the environment

SA7: Value cultural practices and indigenous knowledge

Neuman (2006) identifies essential environmental and geographical skills, such as the expression of ideas and observation through telling simple stories, collecting, classifying, analysing and interpreting data and statistics, and evaluating information from a variety of sources. This is supported by Ruane (2005) and Sterling (1999), emphasising the imperative for learners to think critically, identify causes and consequences of environmental problems, and seek consensus when dealing with contested environmental issues.

Teaching, learning and assessment (TL)

Swarts, Dahlstrom and Zeichner (1999) suggest that the starting point for teaching and learning is the fact that the learner brings to school a wealth of knowledge and social experience gained from the family, the community and the environment. It is for this reason that the MoE (2010) is of the view that learning should be a social process rather than simply a process of transmitting facts. Willingness and active participation are central to the process. The graph in Figure 3 reveals that 54% of teachers were confident to teach with the learner–centred approach. This is not an unexpected finding, considering that Namibia follows a social constructivist philosophy. Literature shows that if learners are involved in value clarification methods such as moral dilemmas, they will be able to see and hear the connection with the real world outside their frame of reference. Moral dilemmas test the environmental convictions of learners, thus facilitating intellectual growth. Miller (2004) and Schnack and Jensen (1997) maintain that this fosters learners' awareness and trains them in how to reach a decision when faced with controversial environmental issues (responsibility and confidence). In interviews, educators cited the use of lecturing, group work, and question and answer methods. This was supported by learners who participated in focus group discussions.

From Figure 3 it is clear that the majority of educators (89%) were most confident to teach environmental issues (TL1) and least confident in using the local environment to do practical activities (TL2). In interviews with learners, they commented that they were rarely required to do practical outdoor activities. Outdoor activities are an example of activities that provide opportunities for learners to develop skills for data gathering, including social skills such as cooperation and appreciation (Palmer, 2003; Schnack & Jensen, 1997). It is therefore a concern that a considerable number of educators did not use problem–solving skills when teaching environment–related issues (TL4). Researchers such as Mukoni (2013) remind us that schools and learners should be involved in practical actions to solve environmental problems in their context.

It was impressive that such a high percentage of educators (61%) reported to be confident – and 25% very confident – that they continuously assess learners' tasks (TL7). Their continuous assessment tasks are, however, limited to chalkboard activities. This study revealed that learner activities had no link with continuous assessment tasks such as projects where a learner's finished product can be assessed using a criterion reference system. Inspection of a sample of learners' exercise books revealed that activities of less than a page were classified as projects.

Figure 3. Educators' rating of teaching and learning indicators in schools
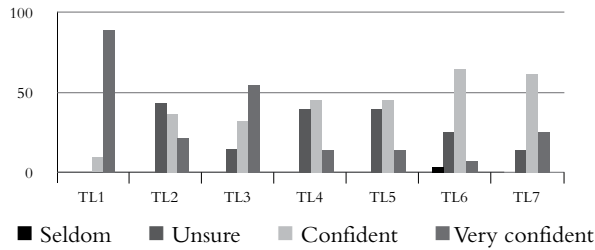
TL1: Feeling of being comfortable talking to learners about EL

TL2: Regular use of the local environment to do practical activities

TL3: Teaching in a learner-centred way

TL4: Use of problem-solving skills

TL5: Teaching importance of identifying people in environmental issues

TL6: Considering ecological cost and benefits of design

TL7: Continuous assessment practices and activities

Learning support materials (LSM)

Learning support materials are critical for the successful implementation of any educational programme. Figure 4 shows educators' ratings on the use of existing official materials (such as text books) (LSM1) and educators' initiatives to gather and develop their own supplementary materials (LSM2). This was supported by the results of interviews with educators.

Figure 4. Educators' use of learning support materials
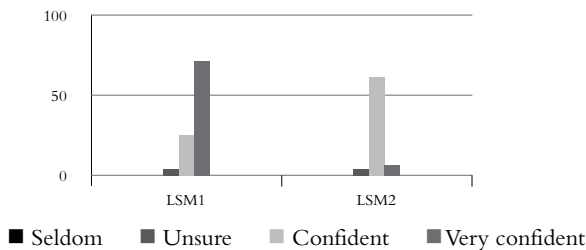
In the self-assessment instrument, 71% of educators indicated that they were confident that they use the existing official learning support materials to teach environmental education-related topics (LSM1); 4% of educators were unsure. Only 7% of educators on the self-assessment instrument specified that they were very confident, and 61% said that they produce or collect supplementary materials/resources to teach environmental education-related matters (LSM2). The result of interviews with educators referred to government ministries, internet, and television documentaries as sources for supplementary materials.

Extracurricular programmes and community support in schools (ECEA)

Figure 5 shows educators' involvement in extra-curricular and environmental action as represented by the listed indicators.

Figure 5. Educators' participation in the extra-curricular and environmental action in schools
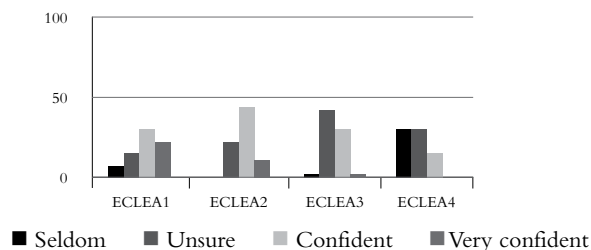
ECEA1: Involvement in extra-curricular activities at school

ECEA2: Communicating responsible citizenship

ECEA3: Communicating various levels of action

ECEA4: Involvement in community EL activities

Figure 5 shows that 21% and 11% of educators indicated that they were unsure and very unsure about their involvement in extracurricular activities respectively. The only common activities cited in interviews were organising learners to participate in a school manual work day and, to a lesser extent, in tree planting and vegetable gardening. Educators did, however, express a willingness to participate in environmental clubs if these were formed at their schools. The quantitative research also revealed the weak involvement of educators in the environmental community education activities (ECEAs); 39% of educators were unsure about their involvement (ECEA4). This was found mostly in urban schools and among female educators. Educators also indicated in interviews that parents are seldom involved in the environmental education activities of schools. Parental involvement was limited to lending garden equipment, such as hoes and spades, during the clean-up activities on school grounds. Schools did not have special national and international environmental days integrated into their school programmes; only a limited number of schools participate in such days. Educators appear to regard activities taking place at school as being entirely separate from those that occur outside of school; therefore, they fail to see that these activities can be complementary and thus beneficial.

Use of outdoor activities and the educators' perception of indigenous knowledge (IK)

Educators interviewed were aware of the importance of indigenous knowledge in terms of sustainable and unsustainable ways of living. Stressing the essential role of local experiences, Schnack and Jensen (1997) suggest that, in order to understand something, we need to explore the context within which the meaning arose. Indigenous knowledge is a rich resource and a path to sustainable living that could be integrated into daily teaching of environmental issues in schools. We can learn from both the positive and negative aspects of indigenous knowledge of local communities. Miller (2004) supports the explanation that surveys carried out in the United States indicated that environmental beliefs of modern society are beginning to weaken and shift toward more environmental views of cultural creation.

Evidence from the quantitative research also indicated that 43% of educators were unsure about whether they used their local environment for practical activities (TL2 in Figure 3). The majority of these were female educators from peri-urban areas.

Issues covered in the school environmental policy

Most schools (86%) did not have environmental education school policies, action plans (89%), or environmental education coordinators (96%). They also rarely participated in national and international environmental days, as mentioned earlier. Schools still focus on addressing issues related to the use of water, littering and health while paying little attention to waste reduction, the use of energy-saving measures, the preservation of biodiversity and the use of environmental clubs in the daily aspects of school life – especially in rural schools.

In-service training needs for Geography educators (ISTN)

The Geography educators were asked what their training needs were. From Figure 6 it was clear that most educators indicated that they needed more professional training on: assessment (71%) (ISTN2); letting learners participate in learning (68%) (ISTN5); greening of their schools (68%) (ISTN6); and field-work techniques (61%) (ISTN7). In fact, educators only indicated a low need for training in philosophical underpinnings (32%) (ISTN8). With this in mind, it appears that professional development for Geography educators should focus on pedagogical knowledge – environmental centres can play an important role in this.

Figure 6. In-service training needs for Geography educators
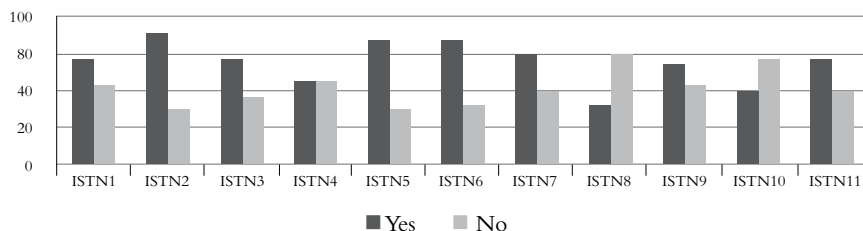
ISTN1: Action research on environmental learning

ISTN2 : Assessment in environmental learning

ISTN3: Local to global learning themes

ISTN4: Case studies on environmental learning practice

ISTN5: Participation of learners in decision-making

ISTN6: Greening of school grounds

ISTN7: Fieldwork techniques

ISTN8: Philosophical underpinnings of environmental learning

ISTN9: Teaching methods in environmental learning

ISTN10: Environmental audit at schools

ISTN11: Environmental learning integration in schools

The role of the environmental education officer

The environmental education officer of the Ministry of Environment and Tourism in the Caprivi region maintained that there is no environmental education centre in the region. These centres can play a role in teacher-training as well as assisting in learners to improve their environmental knowledge. A plan is underway to construct two environmental education centres, one for the Caprivi and the other for the Kavango region. The officer is currently involved with two schools implementing outdoor and sustainable living programmes, so environmental education centres will be a considerable asset. The vastness of the area of responsibility (encompassing 419 schools) and transport problems were cited as hampering the implementation of environmental education programmes in the regions.

The office of the regional environmental education officer (responsible for the environmental education centre) is expected to coordinate field visit programmes, together with the MoE. A regional interministerial committee could be set up to facilitate these programmes, enabling learners to develop an understanding of concepts such as conservation, preservation, beautification and stewardship.

Conclusion and Recommendations

This research has contributed to a better understanding of how Geography educators implement environmental education in schools. Although, overall, the educators are confident that they know enough about environmental education and how to teach it, the study showed that there are some limitations to their actual knowledge and teaching skills. Improved resources, additional training, and departmental and external support through environmental education centres can all play a role in improving educators' abilities to enable environmental education in Namibia's Geography curriculum.

From this research, it seems that educators should:

- Use more opportunities for the creative involvement of learners, other educators and stakeholders in practical school and community activities in order to improve the quality of environmental education in Geography;
- Focus more on the development of a variety of teaching/learning strategies, and the adaptation of learning support materials to meet the diverse needs of individual learners in classrooms;
- Engage more in curriculum-planning approaches that allow the school to take ownership of and expand on national requirements, as well as promoting the subject to parents and learners;
- Reflect more on one another's experiences, sharing professional expertise, resources and strategies, and updating their own knowledge and skills on the subject at all levels;
- Apply continuous assessment and understand the need for a paradigm shift in assessment, with more emphasis on the use of a criterion reference system for learners' projects; and
- Contribute via national or local associations and meetings to discuss the role of Geography in environmental education.

Notes on the Contributors

Callie Loubser is a pioneer in the establishment of environmental education courses at the University of South Africa. He has served on various national bodies, including the Environmental Education Policy Initiative and the Environmental Education Association Council. Email: loubscp1@telkomsa.net

Patrick Simalumba is a deputy director for Curriculum Research and Development at National Institute for Educational Development (NIED), a Directorate in the Ministry of Education, Arts and Culture in Namibia.

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Professional Development in Environmental and Sustainability Education
Voices, Practices and Reflections of Science Teachers

Ronicka Mudaly and Raeesa Ismail, University of KwaZulu–Natal, South Africa

Abstract

A specialised multi-pronged approach is necessary in order for environmental and sustainability content knowledge to be integrated into the Science curriculum. This underscores the need for Science teachers to be innovative in their teaching, and to be supported through professional development. This study aims to explore how professional development at a tertiary institution can be used to support practising Science teachers in curriculum innovation when they teach environmental and sustainability education in the new Curriculum Assessment Policy Statement (CAPS) curriculum. A qualitative approach is adopted in this interpretivist study. The sample comprises ten purposefully selected Science teachers who registered for a Bachelor of Education Honours programme. Drawing on constructs from the Zone of Feasible Innovation (ZFI), which is related to Vygotsky's Zone of Proximal Development (ZPD), practising Science teachers' engagement in curriculum innovation in environmental and sustainability education is analysed. Data were generated using reflective journals, lesson plans, and interviews. The findings suggest that teachers experience challenges related to 'the how' and 'the what' of implementation of environmental education concepts enshrined in the CAPS document. Insights into teacher agency (in terms of content knowledge, teaching strategies and assessment) which catalysed teacher transformation, are presented. The implications of the findings will be significant for education department officials involved in teacher professional development, teacher education institutions, and school teachers themselves.

Keywords: Curriculum innovation, environmental and sustainability education, professional development.

Introduction

'Environmental education (EE) is hard to understand for me even as a teacher … I was not sure how to explain it to learners' (Life Sciences Teacher 3)

'Previously I rushed through the section on environmental and sustainability education just to get through it' (Life Sciences Teacher 9)

The preceding quotes from interviews and reflective journals of practising Life Sciences teachers give credence to the views of Reddy (2011), and Dreyer and Loubser (2014), that although efforts have been made to integrate environmental education into the formal curriculum, its implementation remains problematic. Rogan and Aldous (2005) contend that the reason for this is that the focus has been on the *what*, instead of the *how*, of curriculum implementation. They assert that the capacity of teachers to implement curricula needs more attention, and is not an automatic process. The preceding diary reflections of Teachers 3 and 9, which relate to teaching environmental and sustainability education, attest to this lack of capacity to implement the curriculum.

In this paper, we bring to the centre the views and practices of Life Sciences and Natural Sciences teachers when they teach environmental and sustainability education. We argue that in order for teachers to understand and implement changing curricula, they need to be innovative. We focus on the following research question: How do Science teachers who have engaged in professional development activities enact the curriculum by innovating in environmental and sustainability education?

We begin with a review of the South African school context, where, paradoxically, a consistent feature has been the topic of curriculum change (Reddy, 2011; Rogan, 2007, 2015). This is followed by explicating the connectedness between curriculum change and innovation, and a rationale for focusing on curriculum innovation. Theoretical constructs from the Zone of Feasible Innovation (ZFI) and Zone of Proximal Development (ZPD) are justified and these are linked to subsequent sections on the methodology, professional development (PD), and findings and the conclusion.

Changing curricula in South Africa

After 1994, which ushered in a new democratic order in South Africa, political change and economic redress were emphasised, and a transformed education system was seen as crucial to achieve these goals, which were underpinned by a social justice discourse (Reddy, 2011). Educational reform was based on liberatory ideologies and was implemented rapidly. Curriculum 2005 (C2005) was formulated, underpinned by an outcomes-based education (OBE) approach, which signalled a major shift in teaching and learning between pre- and post-apartheid dispensations in South Africa.

Intensive focus on policy, and less focus on implementation often characterises efforts towards education reform, and this was no different during the post-1994 era in South Africa (Rogan, 2007). To this end, Rogan (2007, 2015) points out that it is crucial for curriculum policy to take into account achievable strategies for implementation within realistic time frames and actual contexts. C2005, however, was not based on a deep consideration of the diverse school contexts in South Africa (Rogan, 2015). The learner-centred pedagogy at the core of C2005 was aimed at reducing 'elitism, and the dominance of the white, male orientation in the curriculum' (Hoadley & Jansen, 2009: 174). A social reconstructionist ideology was intended which focused on education for the empowerment of historically disadvantaged people, was relevant to the lives of learners, and would produce scientifically and technologically literate citizens who were capable of critical thinking (Hoadley & Jansen, 2012). The competence curriculum model

characterised the policy design of C2005 because strong links were made between everyday knowledge and school knowledge. Responsibility for the selection of content, sequencing and pacing was devolved to schools. In this way, the democratic order in South Africa sought to influence education for emancipation.

According to Hoadley and Jansen (2012) under-specification of what should be taught, how it should be taught, and what learners should know at the end of each grade created colossal challenges in the implementation of C2005. Rogan (2007) adds that the adoption of C2005 did not consider the capacities of teachers and contexts of schools. Inadequate teacher and school preparation to enable implementation of a 'new' curriculum through OBE, which enshrined reform ideals, paradoxically deepened the disadvantage experienced by schools in underprivileged settings, and advanced opportunities for success in historically advantaged schools (Tshiredo, 2013). Implementation challenges were linked to the highly complex language used to write the policy, inadequate resources and support for teachers and schools, the inability of teachers to use existing support materials, and a shortage of teacher training personnel. Unrealistic time frames for implementation as well as inadequate monitoring and poor in-service teacher training resulted in poor orientation to C2005 (Chisolm, 2005).

Multiple revisions of the curriculum occurred (from C2005 to the National Curriculum Statement [NCS] to the Revised National Curriculum Statement [RNCS] and presently, the NCS-CAPS). The NCS-CAPS was implemented in 2012. The CAPS curriculum is based on a performance model and the content to be taught, as well as methods to be used, sequencing and pacing, which are all, to a great extent, centrally controlled by the Department of Basic Education (DBE).

The ongoing curriculum reform has been marked by subject changes, for example, Biology was replaced by Life Sciences. One aim of the Life Sciences curriculum is to 'use Science and technology effectively and critically showing responsibility towards the environment' (DBE, 2011:8). Three specific aims are central to this curriculum, the third one focuses on applying scientific knowledge responsibly by considering its effect on the environment. A key purpose for studying Life Sciences is to promote responsible actions towards the environment (DBE, 2011). The content includes environmental studies as one of four knowledge strands, and comprises studies of biospheres, biomes, ecosystems, biodiversity, population ecology and human impact on the environment.

Change and innovation

Environmental education is located within a specific knowledge strand – environmental studies – in the CAPS curriculum, and this represents a change from previous curricula. We concur with Rogan (2015) that in order for teachers to implement changes in curricula, they should be enabled to navigate beyond their familiar boundaries of practice to adopt innovative strategies. We argue that the Science teacher's capacity for innovating is crucial for two reasons. First, innovating in Science education has the potential to enable teachers to adapt to changing curricula. Second, the dynamism of innovating in Science education has the potential to enable teachers to teach more meaningfully (Aleixandre & Santamaría, 2007). The renewal of the curriculum design and its associated practices involves curriculum innovation, which

is characterised by the intersecting influences of research, policy and practices (Williamson & Payton, 2009).

The etymology of curriculum reveals its Latin origin in the word *currere*, which means 'to run' (Van Laren, Mudaly, Singh, Mitchell and Pithouse-Morgan, 2012). The dynamism associated with 'curriculum' results in a change from the noun (a course to be run) to a verb (to run) (Van Laren *et al.*, 2012). Curriculum is therefore conceptualised as ever-moving, ever-evolving. The etymology of 'innovate' reveals it roots in the Latin *innovare*, which means to make new, or to renew (Van Laren *et al.*, 2012). The concept of curriculum innovating is therefore central to this paper because it subsumes ideas of change, renewal, evolution, all within a dynamic context.

A focus on theoretical underpinnings related to curriculum innovation, Vygotsky's ZPD, and how these define the nature of Rogan's ZFI is appropriate. In this paper, the concept *curriculum* is rooted in the social reconstruction ideology. Inequalities which are rooted in socio-historical categories, and which influence teaching and learning contexts in diverse school settings, need to be considered when curriculum renewal is enacted. We argue that the *what* and *how* of curriculum implementation is contingent on a multitude of factors, and we focus on professional development as a means of facilitating the realisation of the intended curriculum.

Curriculum innovating

In order for teaching to remain relevant, curriculum innovating is essential (Ferrari, Cachia & Punie, 2009). Although the view that curriculum innovating must be at the forefront in Science education is widely held, Kirkgöz (2007) and Kärkkäinen (2012) caution against adopting an over-optimistic expectation of this process by illuminating challenges associated with innovation. They contend that curriculum innovating is contingent on factors associated with school contexts, different qualities of teacher training and experience, the presence or absence of support, and the quality and availability of resources such as text books. If Science curriculum innovating is to be sustained, the capacity of research organisations and school systems needs to be enhanced (Fishman & Krajcik, 2003). It is crucial to place the teacher at the centre of the complex process of curriculum innovating (Lamie, 2004). According to Emo (2009), teacher-initiated and teacher-driven innovation is under-researched. Reddy (2011) adds that the pedagogy, as it relates to the teacher who teaches environmental education, needs to be explored. We address this paucity by focusing on how teachers engage in curriculum innovation when they teach about the environmental and sustainability, by tapping into teachers' ZFI.

Honing in on the Zone of Feasible Innovation (ZFI)

The ZFI (Figure 1) refers to innovative teaching strategies which transcend boundaries of current practice, but which are doable and sustainable, within the prevailing school context in terms of material and human resources and the school ethos (Rogan, 2007).

Figure 1. The location of the ZFI on a continuum

ZFI

| Current routine practices | 'Ideal' practice |
| e.g. demonstrations | e.g. student–designed, open–ended projects |

Source: Rogan, 2007:450.

Departing from routine practices into the ZFI depends on 'teacher factors, learner factors, physical factors and school management/ethos' (Rogan, 2015:5). Altinyelken (2010) asserts that the physical infrastructure and material resources of the school determine the school's capacity to innovate. She asserts that a well–managed school under visionary leadership can influence a teacher's motivation and capacity for innovation positively. Factors which support innovation by teaches include: commitment, willingness to adapt to or lead change, willingness to collaborate, excellent content knowledge, and qualification for the subject (Rogan & Aldous, 2005). Responsible, self–regulating, independent learners who willingly attempt new ways of learning and who are fluent in the language of instruction, can contribute to curriculum innovating, according to Rogan and Aldous (2005).

Rogan (2015:6-9) mentions four steps involved in the construction of the ZFI. First is the designing of a continuum by school personnel, which takes into consideration existing internal and external elements (e.g. national curriculum policy, what is deliverable by the school) which favour curriculum implementation. Second, school personnel consider the available resources within and outside of the school, then plan the sequence of implementation on the continuum. Subject matter and school context are carefully examined to consider how the teacher can adapt or improvise, given the prevailing resource allocation. Third, school–based managers focus on where current teacher practice is located on the continuum, and what innovation is possible in the immediate future, given the school context. Individuals tasked with implementing innovative strategies are selected, and the extent of the implementation in terms of the boundaries of the ZFI are identified. Plans are made to obtain support from other schools which have implemented new teaching strategies successfully. In the fourth and final step, implementation within the ZFI takes place. Teachers in the same district can work together and test ideas related to curriculum innovating, and this can facilitate social learning. This social learning is embedded in theoretical constructs from Vygotsky's ZPD which underpin the ZFI (Rogan, 2015).

Vygotsky emphasised the importance of the social environment in the learning process. He contended that logical thinking is initiated and enabled by members in a group setting. According to Vygotsky, more knowledgeable others assist children in progressing beyond the existing ability level, thereby moving them into the ZPD. They then appropriate the knowledge, which was first acquired in a social setting (inter–psychological), as their own (intra–psychological). Vygotsky's ZPD overlaps with Rogan's ZFI because both can apply to teacher learning which occurs during professional development. Moving into the ZPD

or ZFI involves moving into an experimental stage of learning en route to internalising the practice or concept. Motivation to move into the ZFI involves a willingness to experiment with curriculum innovating and to incorporate successful innovations into one's own practice. This motivation could be rooted in professional satisfaction (internal factor) or the pressure to comply with policy (external factor) (Rogan, 2007:446).

Rogan's positioning of the teacher as a learner is different from the way Vygotsky conceptualised the learner. Rogan (2007) asserts that when one positions the teacher as a learner within a workshop setting, one needs to be cognisant that the teacher, unlike the lead expert, is responsible for actually implementing the curriculum. In Vygotsky's ZPD, the more capable other (e.g. the expert/adult teacher) is largely responsible for the learning which takes place; while in the ZFI, the choice of appropriate innovation is the responsibility of the teacher, even when the teacher is positioned as a learner within the workshop. While the ZPD focuses on 'appropriateness of new conceptual material' which, although they are new to the learner, are within the learner's cognitive reach, the ZFI focuses on 'appropriateness of innovative practice' which can be implemented within a particular context (Rogan, 2007:248). A practice cannot be implemented without cognitive understanding in the ZFI. Therefore, Rogan (2007) contends that moving into the ZPD and/or the ZFI is contingent on cognitive development, and in this paper, we examine the role of professional development in moving teachers into the ZPD and ZFI.

Methodology

A qualitative methodological paradigm was employed in order to obtain an in-depth understanding of how teachers could be supported to innovate in environmental and sustainability education. Ten purposefully selected teachers, out of a class of 32, formed the case to be studied. The criteria for their selection were that they should have been practising Life Sciences or Natural Sciences teachers, and were enrolled to study the Curriculum Development in Mathematics and Science Education module, which was one out of eight modules in the Bachelor of Education Honours programme. Multiple data generation methods, including document analysis, individual interviews, photo narratives and reflective journaling, were used. For the purpose of this paper, the following data sets were analysed: reflective journals, individual interviews and lesson plan documents.

The teachers were given five tasks (presented in Appendix 1), which were sourced or adapted from the article by Rogan and Aldous (2005) and from materials generated for the Fundisa for Change programme.[1]

The teachers' responses to the tasks were summarised in portfolios of evidence. The ten teacher participants were interviewed about their practices, and they recorded their experiences related to innovating in environmental and sustainability education in reflective journals over a period of ten months.

Each of the teachers was fully qualified to teach Life Sciences and/or Natural Sciences. The participants taught in diverse socio-economic settings and, with the exception of P6 and P9, each teacher had less than ten years of teaching experience.

Table 1. Profiles of participants

	Race	Gender	Subjects currently teaching	No. of years teaching Life Sciences and or Natural Sciences	Type of area which school serves
P1	African	Female	Life Sciences and Natural Sciences	3	Middle-class socio–economic community.
P2	Indian	Female	Life Sciences and Natural Sciences	2	Lower to middle-class socio-economic community. Some learners come from townships.
P3	African	Male	Information Technology and Natural Sciences	1½	Lower socio-economic community. Most learners come from townships and underprivileged backgrounds.
P4	Indian	Female	Life Sciences and Natural Sciences	8	Lower to middle-class socio-economic community. Some learners come from townships and underprivileged backgrounds.
P5	Indian	Female	Life Sciences and English	1	Lower to middle-class socio-economic community. Some learners come from townships and surrounding area.
P6	African	Female	Physical Sciences and Natural Sciences	19	Lower socio-economic community. Most learners come from townships and underprivileged backgrounds.
P7	African	Male	Physical Sciences and Natural Sciences	3	Affluent community.
P8	Indian	Male	Natural Sciences and Life Sciences	1	Lower to middle-class socio-economic community. Some learners come from townships and underprivileged backgrounds.
P9	Indian	Male	Natural Sciences and Physical Sciences	25	Lower to middle-class socio-economic community. Some learners come from townships and underprivileged backgrounds.
P10	Indian	Male	Natural Sciences and Mathematics	7	Lower to middle-class socio-economic community. Some learners come from townships and underprivileged backgrounds.

The connectedness among theoretical constructs, methods and methodology is important to show how this particular kind of PD promoted opportunities for teachers to advance into the ZFI and ZPD.

Professional development: Translating theory into practice

We adapted Tytler, Symington and Smith's (2011) constructs of PD to create a model (Figure 2). We also borrowed from Frost's (2012) criteria for PD as an engine for active curriculum innovation – as opposed to being a vehicle for passive curriculum implementation – to inform our analysis of the PD module activities (Tasks 1 to 5 in Appendix 1).

Figure 2. Authors' model illustrating the key features of curriculum innovation
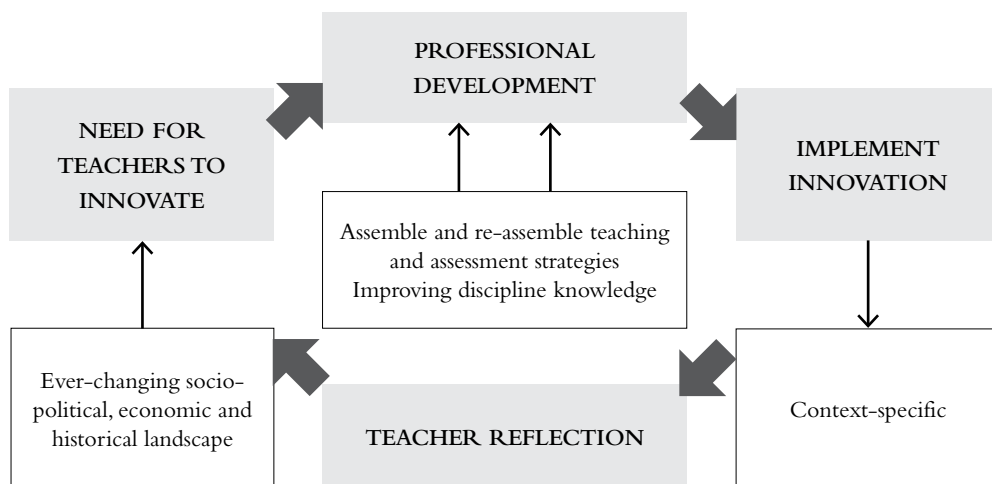
Source: Adapted from constructs from Tytler *et al.*, 2011.

Teachers' willingness to innovate is crucial when new curricula are implemented (Chee, Mehrotra & Ong, 2014). We posit that teachers' belief in the need to innovate is a factor which can motivate teachers to innovate. This was achieved in the PD module by engaging teachers in the reading and group discussion of an article (Tasks 1 and 2). Deep thinking in a social environment was enhanced in this way, and this strategy was informed by Vygotsky's contention about the value of learning in group settings (Rogan, 2015). The PD module required that teachers appraise their context closely (Tytler, 2009) in order to determine what change is feasible and realisable (Task 3). The teachers were encouraged to be professionally accountable (Frost, 2012) by improving their content knowledge through research (Task 4). Based on their knowledge about innovation, their enhanced knowledge about their school context and their enhanced disciplinary knowledge, teachers planned lessons with assessment activities (Task 5.1). They were expected to have their lesson plans reviewed by a senior colleague, and revise them based on the review. This was informed by constructs from both the ZPD and ZFI. The senior teacher played the role of 'expert' (ZPD), and assisted teachers by enhancing their knowledge of pedagogy and content. Teachers also engaged in deepening their pedagogical and content knowledge independently in order to move into the ZFI. In this way, teachers were active agents in their own PD (Gulamhussein, 2013), as they were requested to revise their lesson plans (move into ZPD and ZFI) and implement the lessons (Task 5.4). Finally, they reflected

on their lessons (Task 5.5) with a view to improving future teaching, based on the support that they could leverage (ZFI). At each stage, teachers were encouraged to 'assemble and re-assemble teaching and assessment strategies (Tytler *et al.*, 2011).

Findings

Content analysis of interview transcripts, reflective diaries and lesson plans resulted in the emergence of two themes, namely:
- Challenges teachers had experienced when they had taught environmental and sustainability education, before engaging in the Honours module.
- Changes in teachers' attitudes and practices after they had studied the Honours module.

The following abbreviations are used:
P   participant
II   individual interview
RJ   reflective journal

Challenges in the classroom
The participants experienced four key challenges when teaching environmental and sustainability education:
- Lack of content and pedagogical knowledge;
- Ineffective professional development by the DBE;
- Lack of support from school management; and
- Inadequate teaching resources.

Table 2: Challenges experienced by Science teachers in the classroom (before they engaged in the Honours programme).

Themes	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Lack of content knowledge and knowledge of teaching strategies/ methods to successfully teach environmental and sustainability education	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ineffective professional development provided by Department of Basic Education	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lack of support from school management	✘	✓	✘	✘	✘	✘	✘	✘	✓	✓
Lack of resources in school	✘	✓	✘	✘	✘	✓	✘	✘	✓	✓

✓ Indicates that the participant experienced that theme as a challenge.
X Indicates that the participant did not experience that theme as a challenge.

Lack of content and pedagogical knowledge
Regardless of their teaching experience, which ranged from one year to 25 years, each participant indicated in their reflective journals that they felt lacking in the pedagogical practices related to teaching environmental and sustainability education, and the following excerpts provide evidence to this effect:
- 'I did not know how to teach EE before the professional development' (P1 – RJ)
- 'To teach it is hard, I struggled to find a method that simplified the concepts for learners to understand' (P10 – RJ)

The following individual interview responses corroborate views expressed in the journals:
- 'Teaching it was really challenging because the textbooks were not clear … they have examples that are hard for learners to relate to' (P7 – II)
- 'I was not confident teaching environmental and sustainability education to learners because I did not have any method to make it easy for them' (P9 – II)

The rapidly changing curricula from C2005, to the Revised National Curriculum Framework, to the CAPS, was accompanied by a change in teacher education programmes. It is possible that there was *inattention* to environmental education (Fein, 1991), or a *lack* of environmental education (Lotz & Robottom, 1998) or a *neglect* of environmental education (Lotz-Sisitka, 2011) in teacher education programmes, which resulted in teachers being unable to understand environmental education. These factors could also have contributed to teachers' inability to use apposite teaching strategies to facilitate teaching and learning. An unconfident teacher of environmental and sustainable education is problematic, and needs the attention of relevant stakeholders. The inability of teachers to understand environmental and sustainability education limits their conceptual frameworks for dominant social discourses (Lotz-Sisitka, 2011). Teachers' lack of conceptual depth has 'implications for pedagogical content knowledge' (Lotz-Sisitka, 2011: 32).

Ineffective professional development
All the teachers in this study had attended professional development workshops hosted by the DBE. These teachers decried the effects of these workshops on their knowledge and practices by articulating the following evaluations of workshops in individual interviews:
- 'I have been for once-off workshops that are really not worth my time' (P2 – II)
- 'Many workshops I have been for never start on time and the facilitator just reads the CAPS document to us' (P4 – II)
- 'I've been for the workshop but I got nothing on how to teach concepts' (P5 – II)
- 'Going for workshops are sometimes a waste of my time because I lose out on teaching time and don't even gain anything useful' (P8 – II)

These opinions were endorsed by the following journal entries:
- 'Once-off workshops never gave me anything to help me to teach … they just read through the CAPS document' (P4 – RJ)

- 'Just going for two hours for a workshop can't really help me to be a better teacher all it does is give me more work when I get back to school to catch up syllabus. If I learnt something useful then I would not mind' (P9 – RJ)
- 'The workshops never taught me anything and I lost out on time to teach … I asked my HOD not to ask me to go for the next workshop' (P10 – RJ)

Teacher participants understood that short workshops could not serve to remedy their inadequate content knowledge or pedagogical knowledge. Their frustration about the workshops not being 'worth their time' and retarding their coverage of syllabus was possibly aggravated by the poor organisation of workshops and poor preparedness of the facilitators. Insufficient teacher training and ineffective in-service professional development by the DBE has been well documented (Nkosi, 2012; Bertram, 2012; Reddy, 2011; Lotz-Sisitka, 2011).

Lack of support from school management
In the experiences of three out of ten participants, the challenge of teaching environmental and sustainability education effectively was exacerbated by the lack of support from members of the school management. Individual interview responses to this effect included the following:
- 'My HOD doesn't like young teachers giving ideas or new ways to teach so I am reluctant to ask questions or give suggestions' (P2 – II)
- 'My HOD is not very approachable he just wants the work to be completed his way … if I could ask for help I would' (P9 – II)
- 'The school management is not interested in the way we teach … I would appreciate help' (P10 –II)

These were buttressed by the following journal entries:
- 'because my HOD is not helpful I just teach it without any help' (P2 – RJ)
- 'It's hard but I don't have support from the management … some help when I am stuck would benefit my teaching' (P10 – RJ)

Except for two participants (P6 and P9), all the teachers in this study had less than ten years of teaching experience. It is expected that novice teachers would have received mentorship and other forms of support, and this seemed to be the case in most of the participants' experiences. However, in the case of the three teachers who indicated otherwise, the structural domination of school managers constrained their agency.

Inadequate teaching resources
Four out of ten participants indicated that they experienced a lack of resources at their respective schools. This lack of resources had a direct impacted on these participants' efforts to be innovative when they taught environmental and sustainability education. These individual interview responses attest to this:

- At my school we don't have enough textbooks, learners share between three sometimes … (P6 – II)
- We can't run out worksheets for learners due to a lack of funds (P9 – II)
- Textbooks are an issue, sometimes the diagrams are wrong or the notes do not make sense (P10 – II)

The above responses are affirmed by the subsequent journal entries:

- Teaching without worksheets is difficult because drawing and writing notes is time consuming (P6 – RJ)
- Learners share textbooks so teaching is slow and difficult. One textbook was unclear … (P9 – RJ)

Two of the four participants felt severely constrained by the lack of resources. However, the other two participants (P2 and P6) who also experienced a lack of resources at their schools viewed this challenge as a stepping stone towards curriculum implementation. The following responses which emerged from individual interviews attest to this:

- Even though we are not a well-resourced school, I go out and get my own resources; I borrow, make my own and sometimes even purchase my own resources (P2 – II)
- I am in an under-resourced school but I try to get my own resources. I borrow from other teachers (P6 – II)

These participants demonstrated their increased capacity to implement the curriculum by creating or acquiring their own resources to assist them in teaching environmental and sustainability education.

Changes in teacher practice after the professional development programme
All participants had engaged in developing units of work and in teaching this work, as part of the Curriculum Development in Science and Mathematics module in the Honours programme. Participants' responses revealed that this activity (developing and teaching unit work) effectively exposed them to ideas for innovative teaching. Table 3 provides a summary of their past and present lesson plans.

Table 3. Summary of previous and current lesson plans

Topic Grade Subject	Past and present teaching practice	Strategies and resources	Source	Teacher input
Greenhouse effect Grade 7 Natural Sciences	Previous strategy	Read from text book. Summarise points.	Prescribed text books	Transmitted information in text book without considering context of learners.
	Present strategy	Learner-centred games. Word-match game. Wordsearch. Word puzzle.	Internet: Global Warming Activity pack	Adapted to suit local context.
		Practical investigation: Observe the Greenhouse effect in a jar.	Franklin Institute Resource for Science Learning	Generated assessment worksheet to assess knowledge of apparatus and method, and skills of observation. Higher-order question included consideration of how the investigation could be improved.
Ecotourism Grade 10 Life Sciences	Previous strategy	Use prescribed learner workbooks. Read and respond to activities.	Prescribed learner workbooks	Facilitated student's reading and check correctness of their answers.
	Present strategy	Group work. Learners read materials about biological control, subterranean life forms, invasive plant species, and impact of humans on biodiversity in South African cities.	Durban Natural Science Museum Environmental Management Department: Ethekwini Municipality	Worksheet was developed to answer questions based on the materials, and to give personal opinions about ecotourism. Poster presentation activity is given about how humans reduce biodiversity in South African cities.
Atmosphere Grade 9 Natural Science	Previous strategy	Run out worksheets or write notes on the chalkboard.	Prescribed text book	Select notes/activities and create or copy worksheets.
	Present strategy	YouTube video: Atmosphere in motion. Stimulate class discussion about dimensions of layer of atmosphere. CBS news item: Stimulate class discussion on effects of greenhouse gasses on the atmosphere, and resultant effect on all life forms. eNCA news clip: Local industries to which students can relate; and the effects of pollution from these industries on the atmosphere.	Internet	Group task was designed where learners had to work collaboratively to research how humans impact the local environment negatively, and present their findings using pictures and graphs.

A marked shift from past to present teacher preparation and practice is evident in the table. For their present lessons, teachers developed original resources, engaged learners in collaborative learning through group discussions, and tapped into learners' creative abilities by requiring them to develop and present posters. They acquired resources from places used for outdoor learning, such as museums and municipal offices, and gave legitimacy to learners' views by seeking their opinions on human impact on biodiversity; in this way, they created context-specific learning opportunities. Some teachers used YouTube videos and current news clips to teach socially relevant environmental education. They acquired resources from the internet to created entertaining learning games. Teachers also adapted resources from internationally acclaimed institutes (such as the Franklin Institute for Science Learning).

Participants were interviewed about their lessons which they planned and taught as part of the Honours module requirement, and they provided the following views about the module:

> It has positively impacted on my teaching… I feel renewed… I feel rejuvenated. I was caught in the rut of just teaching without concern for learners, but now I changed and motivated to encourage learning. (P4 – II)

When probed for specific aspects of the module which made her feel rejuvenated, P4 said:

> I became aware of other ways of teaching environmental and sustainability education. I did not have the relevant knowledge and skills required to be an innovative teacher but the lectures (in the module) and the lessons I taught on innovation changed that.

On how the module activities enabled innovative practice, P2 asserted:

> I felt as though the activity on the innovative lesson really renewed the way I was teaching environmental and sustainability education. To actually see how one can be innovative in their teaching really gave me a lot of confidence to try and be innovative myself. I learnt something new and this was incredible for me. It was a liberating experience for me. The activities made me come out of my shell and be more creative and critical in my thinking. I believe this was something that I needed, even though I did not know I needed it. (P2 – II)

Other participants expressed the following views:

> Planning and teaching an innovative lesson really exposed me to the idea of teaching using innovation. The lesson I taught was exciting for the learners so that rejuvenated my teaching. (P7 – II)

> I was empowered by the knowledge that I gained from the module. I gained new methods of teaching and strategies from other teachers in the module, to increase learner involvement in lessons. I feel that it is important to include all learners in a lesson and now I have the tools to do this. (P9 – II)

Participants' responses expressed a renewed desire and confidence to teach environmental and sustainability education. They learned from other teachers' presentations in the module, and appropriated some of the ideas as their own. The participants revealed that, for the lessons they had to plan and teach, innovation was the catalyst for their rejuvenated and renewed attitudes towards teaching environmental and sustainability education. This was affirmed by their journal entries.

This renewed confidence, motivation and feeling of empowerment for participants came directly from the fact that they were exposed to new knowledge regarding innovation. The above-mentioned responses of participants indicate that, previously, they had little or no knowledge of how to be innovative. This speaks directly to the effectiveness of the professional development modules. These participants experienced challenges (lack of confidence/ motivation) that required effective professional development. This correlates with Singh's (2011) assertion that effective professional development should address the individual, contextual needs of a teacher.

Closely associated to the increased confidence and motivation of participants is the transformation in planning and teaching practice. The subsequent responses emerged from the individual interviews:

> I feel transformed by the fact that I have new knowledge and different methods to help me teach now. Previously I did not have too many methods, but now I know that with some creativity I can teach environmental and sustainability lessons that learners benefit from. (P1 − II)

> This professional development enabled me to think and practice different ways to teach Natural Sciences. (P3 − II)

Participants were asked about what triggered their transformation, and they offered the following insights:

> What triggered a transformation in me was that I had knowledge of innovation in the form of notes and I also had experience of teaching an innovative lesson. I know that it works and learners enjoy it and learn, so I feel that it was what triggered a transformation in me. I realised that my old ways of teaching would not work anymore. (P3 − II)

> I feel as though I have transformed as a teacher … The positive responses of the learners triggered a transformation in me. Even the quiet ones in the class are now participating in the lesson. (P5 − II)

> Learners' participating in the lesson and showing me that they are learning. I am transformed knowing that I can teach using exciting and attractive activities for learners to understand better. Some learners never used to participate in the lesson and now they do. (P7 − II)

These journal entries affirms the above responses:

> I was bored using the textbook and notebook, to teach now I feel transformed in the classroom. (P8 – RJ)

> I find that you naturally have it in you to be innovative, but all you need is the support or the push to do it. This honours module was actually a catalyst for my change. (P1 – RJ)

A majority of responses from participants indicated that the source of transformation for them was the positive responses of their learners to their innovative teaching methods. From this it is evident that the response of the learner to a new teaching style is critical for the teacher to adopt and/or sustain the practice. This concurs with Guskey's (2002) assertion that when a teacher implements a new teaching method in the classroom, it is the performance of the learners that determine whether or not the teacher espouses the new teaching methods as practice.

Discussion

The need for teachers' professional development to underscore subject knowledge and pedagogical content knowledge in environmental and sustainability education has been widely documented (Lotz-Sisitka, 2011; Mifsud, 2012; Reddy, 2011). The professional development module in this study provided teachers with the opportunity to learn by deepening and widening the scope of their knowledge, attitudes and skills, and creating the space for them to improve their professional competence in environmental and sustainability education. The newness of their teaching strategies energised them; it boosted their confidence in their ability to teach, it was 'incredible' and 'liberating'. It awakened their creative potential and capacity for critical thinking and changed their practice. The teachers engaged learners in activities which made them excited to learn and participate, and encouraged previously passive learners to become involved in knowledge construction.

Teachers in this study progressed from existing practices to new, innovative practices. The entire school was not involved in this study's curriculum innovation, therefore the steps from constructing the continuum to implementing the ZFI were not engaged with by all the stakeholders. Three teachers did not enjoy the benefit of enabling managers, and their views remind one of the negative consequences of 'managerial postures opposed to teachers' work' (Lea, 2012:41).

An examination of teacher factors reveals that each teacher was fully qualified to teach Science, and each teacher had had in-service teacher professional development. The teachers were dissatisfied with professional teacher development programmes offered by the DBE. They viewed their professional growth from the Honours module more positively, and indicated that it resulted in their 'coming out of their shell'. Some teachers believed that their schools were poorly resourced because they could not access printed material. However, when they engaged in curriculum innovating, they obtained materials from other sources, such as museums. They also used digital information to create their own resources or to use directly in their teaching.

These actions suggest that teachers progressed beyond the boundaries of current practice into the ZPI.

Conclusion

The findings in this study reveal that a professional development module was effective because it created opportunities for teachers to become self-regulating by providing them with strategies to actively research topics and deepen their disciplinary knowledge. The module also promoted the value of innovation in Science education. Drawing on constructs from the ZFI, teachers engaged in a conscious examination of their school context as these relate to teacher factors, learner factors, physical resources, school management and school ethos. This information provided them with the knowledge of how they could teach innovatively by using existing resources, or leveraging resources using different methods. They valued the critique of their lessons from more knowledgeable teachers and revised their plans to teach. Social learning was enhanced when they presented their lessons to their peers who were also studying the module. They shared their ideas and incorporated teaching strategie learned from their peers into their own practice. The professional development module created space for experimentation, sharing, constructive critique from others, and deep, critical self-reflection on one's own practice. This generated transformational learning; it cultivated courage to do things differently, and culminated in transformed practice. Teachers' confidence in their own potential to be effective practitioners in environmental and sustainability education soared. Their enthusiasm to teach innovatively was bolstered by a renewed sense of epistemic credibility, and they planned to sustain their practices because learners participated more actively and shared in their teachers' excitement. Teachers' conscious choice to learn new ways of teaching contributes positively to the implementation of a reformed curriculum, and can address the call for learners to 'acquire knowledge and skills needed to promote sustainable development' (UNESCO, 2015:vi), through professional development.

Notes on the Contributors

Dr Ronicka Mudaly is a senior lecturer in science and technology education at the University of KwaZulu-Natal. A science education which is socially just and more relevant, inform her research interests. Email: mudalyr@ukzn.ac.za

Ms Raeesa Ismail is a PhD candidate at the University of KwaZulu-Natal. Her research interests include responsive science teacher education programmes.

Endnote

1. The Fundisa for Change Programme prepares teachers to enhance their knowledge in environmental and sustainability education, as this relates to content knowledge, pedagogical knowledge and assessment. The programme was initiated by members of the Environmental Learning Research Centre at Rhodes University in Grahamstown, South Africa.

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Appendix

The following information was given to the teachers in the PD module:

South African teachers have experienced numerous planned educational changes during the past two decades. Designing and implementing curricula are complex tasks. In this assessment task, you are required to interrogate policy documents and design a unit of work based on biodiversity (Life Sciences) or climate change (Natural Sciences). The unit needs to be reviewed by a peer. The curriculum must then be implemented and recorded using photo-narratives. The planning and implementation must be analysed.

Task 1: Read the following article by Rogan and Aldous (2005) 'Relationships between the constructs of a theory and curriculum implementation' in *Journal of Research in Science Teaching*, 42, 3. pp. 313-336.

Task 2: Engage in a class discussion of profiles of implementation, capacity to innovate and outside influences, which are three central constructs in Rogan's ZFI. These examples apply to Science education.

Task 3: Getting to know your context, your school and students.

1. Briefly describe your school in terms of its population of learners, number of learners doing Life/Natural Sciences, academic performance in the subject.
2. Refer to Appendix B, Table 2 (Rogan & Aldous table which shows profile of implementation, capacity to innovate and outside influences). Describe current learner factors, school management and ethos, physical resources, and teacher factors which are related to innovation in learning.

Task 4: Deepening your subject content knowledge.
Information research: Select a key concept which relates to biodiversity (Life Sciences) or climate change (Natural Sciences) from the CAPS curriculum. Find at least two resources (e.g. textbooks, internet, field guides, journals, newspapers, periodicals) to extend your knowledge of biodiversity/climate change. Complete an analysis of the two resources.

Task 5: Plan and improve your teaching practice.

5.1. Plan two lessons to address the specific topic you have researched. Include realistic strategies which would make your lesson more innovative. Ensure that you select methods appropriate to the concepts, skills and values that are included in CAPS and which are relevant to learning. Include an assessment activity in your plan.
5.2. Ask a senior teacher to review your plan and to write a report on your plan.
5.3. Revise your lesson plan based on the report.
5.4. Implement your lesson plan. Take four photographs which show significant moments related to innovation. Provide a description of the teaching/learning interactions for each photograph.
5.5. Reflect on the activities you have described. Describe how you could improve on the activities for each lesson. Explain how elements in Task 3.2, could change to support the improvement you envisage.

Towards a Theory–Based Framework for Assessing the Mainstreaming of Education for Sustainable Development
A Case Study of Teacher Education Institutions in Botswana

Jesse Schrage, Centre for Environment and Development Studies (CEMUS) and Frans Lenglet, Swedish International Centre of Education for Sustainable Development (SWEDESD), Uppsala University, Sweden

Abstract

This article presents the development of a theory-based framework for exploring the ways in which different teacher education institutions in Botswana have worked towards the infusion of education for sustainable development (ESD) in the curriculum and the practice of pre-service teacher education. The framework combines a theory of change, a theory of education for sustainable human development and a theory of transformative learning. The objective of this paper is to understand how this theoretical framework can help the analysis and understanding of critical features of ESD pedagogy and projects. The research results obtained in the framework's application highlight key elements enabling the successful implementation of ESD in two specific teacher education institutions, namely: the educators' capacity to foster transformational pedagogies in the classroom, their capacity to strategically plan and implement their change projects, and the wider institutional and administrative context.

Introduction

This article focuses on the development of a framework for identifying critical features of innovative pedagogical practice in teacher education institutions wishing to adopt, embed or mainstream education for sustainable development (ESD). It is in response to the need for 'theorising change, and developing praxis–oriented models of change that can be used to fast–track and support ongoing transformation of higher education programmes' (Lotz–Sisitka, Agbedahin & Hlengwa, 2015:17). The theory-based framework attempts to capture ESD's complexity in terms of the underlying pedagogy and change processes. We argue that this framework can provide support and anchor teacher education institutions wishing to mainstream ESD in their local context.

The necessary data were gathered as part of Schrage's study (2015), which developed an earlier version of the framework while conducting an assessment of ESD practice in six teacher education institutions in Botswana. These institutions were participants in a programme of embedding ESD in teacher education in southern Africa; the programme, entitled Education for Strong Sustainability and Agency (ESSA), started in 2011 (SWEDESD, 2016).

This paper, after describing the specificities of the context in which it is implemented and discussing the proposed framework, aims at critically evaluating the utility of the provided framework by looking more closely at its application in two teacher education institutions

selected from the original data set. Through this, the paper identifies the potential strengths and limitations of its use.

Background: ESD in Botswana

Before turning to a discussion of the framework's application in assessing ESD-related change projects in teacher education institutions in Botswana, a brief description of the official ESD context in that country is warranted. Since 1994, the government of Botswana has recognised the importance of environmental and sustainability education. At this time, the National Education Commission stressed the necessity to teach and infuse the curriculum with the concept of environmental education (EE) (Government of Botswana, 1994). The policy required both serving teachers and pre-service teachers to be introduced to EE (Ketlhoilwe, 2007) with the aim of affecting a change in attitudes and increased civic participation of their students (Government of Botswana, 1994).

Today, the implementation of EE at a national level is guided by the National Environmental Education Strategy and Action Plan documents (Government of Botswana, 2007, 2014). Its aim is:

> to develop a society that is aware of and concerned about the environment and its associated problems; a society which has the knowledge, skills, attitudes, motivation and commitment to work individually and collectively towards solving current problems and preventing new ones. (Government of Botswana, 2014:1)

The extent to which the implementation of EE in Botswana has been successful has been the subject of much scrutiny. A study by Ketlhoilwe (2003), focusing on education officers and school heads, argues that EE suffered from conceptual vagueness and misconceptions. Mosothwane and Ndwapi (2012) explain that, at the time of their study, EE was still not embedded into the teacher education programme at the national level, so teachers did not feel equipped to explain environmental issues to children. Nkambwe and Essilfie (2012) and Tsayang and Kabita (2013) elaborated and showed that there is still a limited understanding of what EE and ESD mean both in conceptual and practical terms for teachers and teacher trainers in Botswana.

It is against this background of a relatively favourable and conducive policy climate, combined with serious limitations in the way in which policy intentions are operationalised and implemented at the level of teacher education institutions and schools, that in 2011 all teacher education institutions in Botswana were encouraged to participate in the ESSA programme and to undertake ESD-related change projects in their home institution.

The ESSA programme was initiated through a partnership between the Swedish International Centre of Education for Sustainable Development (SWEDESD) at Uppsala University, the SADC Regional Environmental Education Programme (SADC-REEP), 42 university-based teacher education departments and stand-alone teacher education institutions in southern Africa, and Jönköping University in Sweden. The programme's aim was to support 'teacher educators and their institutions to introduce innovative methods and relevant content related to education for sustainable development in their syllabuses and working practices'

(SWEDESD, 2016:1). The programme wished to encourage institutional change by enabling the creation of structures and policies for embedding sustainable development in the classroom. The programme addressed heads of teacher education institutions as well as teacher educators in order to achieve synchronisation between policy and practice.

The programme relied on the development and implementation of 'change projects', initiated by teacher educators in their home institutions, as a way of creating momentum for institutional change with regard to ESD assimilation at the national level. The change projects aimed at mainstreaming ESD in the curriculum and pedagogical practice of teacher educators. The ESD-inspired curriculum and practice were expected to affect the competences of the (pre-service teacher) students, and subsequently affect their actual performance in the schools where they would be posted. The change projects were a way for the participating teacher educators to develop a deeper understanding of ESD as their project was applied to the local needs and contexts of their home institutions.

Theoretical Framework

The framework for this paper was developed through identifying the elements that support or inhibit ESD's mainstreaming in educational institutions. The framework builds on an understanding of institutional change by combining three theoretical constructs. In this case, the institutional change concerns the introduction of ESD (its content and methods) in teacher training institutions. Connell and Klem (2000) explain that projects in a formal education context, such as the cases presented here, are by their nature complex and dynamic. Therefore, determining their effects and impacts requires a theoretical framework that is sensitive to a variety of elements including, among others: the way ESD is understood by individual instructors or administrators; the nature of the change project itself; the context in which the change project is implemented; the practices that are being targeted for change; and the wider administrative or institutional context. To capture this complexity, a combined set of different lenses is required.

The theoretical framework developed for this paper comprises three conceptual lenses: a theory of change (TOC), a theory of education for sustainable human development (TESHD) and a theory of transformative learning (TTL). The TOC helps with (a) understanding the conditions and processes that lead to the formulation and implementation of a change project, and (b) explaining how certain internal and contextual drivers are likely to affect its outcome. It helps to trace and manage the path taken by an entity in relation to the goal it has set for itself. The second lens, the TESHD, looks at how certain educational practices can lead to greater agency in learners, what Tilbury (2011) called 'learning to respond' – one of ESD's central learning objectives. The TESHD gives insights into the pedagogical practices that support ESD with a special focus on dialogue and deliberation. Finally, the TTL goes one step further and elucidates how certain ESD-related practices can lead towards a new understanding of complex, interconnected and wicked sustainability issues.

Together, the three theories, which are described in greater detail below, combine to form a dynamic evaluation framework. They can be used differentially, depending on the characteristics of the stakeholders involved in the change project/s and their particular circumstances. For

example, when gathering data for the research reported in Schrage's study (2015), the TOC was exclusively used in relation to the change project coordination teams. It brought out the complexity and dynamic nature of the purported change. The TESHD and the TTL guided the data collection with both student-teachers and teacher-instructors in order to understand the pedagogical content of the ESD-related change projects from a variety of perspectives. Crucially, these two last theoretical frames provided support for the articulation of ESD in the classroom.

Theory of change

The TOC used in this study is associated with programme and project evaluation, and informed social action. It was devised for the evaluation of complex community initiatives and originated with the work of Fulbright-Anderson, Kubisch and Connell (1998). They propose a guiding framework (a pathway) to discuss the sequence of events that leads to a particular desired outcome. This TOC has been applied in assessing educational reform in a variety of contexts, such as Mathematics and Science (Connolly & Seymour, 2009); early childhood and community school linkages (Geiser, Rollins & Blank, 2013); and district–wide and school reform initiatives (Fullan, 2006; Gambone, Klem, Moore & Summers, 2001). Connell and Klem (2000) argue that the TOC helps in the planning and assessment of education reform initiatives in an urban environment. It helps in making the reform plans more relevant and sensitive to local realities, as well as in building a local knowledge base and enabling evaluation that is more rigorous and timely. It fosters the creation of collective ownership, which is necessary for the project to be driven forward (Fullan, 2006).

Despite its wide application, the TOC approach suffers from conceptual shortcomings: the concept does not prescribe specific evaluative methods, or the way the theories of change are articulated, or indicate who the TOC's 'owners' are (Blamey & Mackenzie, 2007; Sullivan & Stewart, 2006). TOCs have been formulated and implemented in a wide variety of ways (Mason & Barnes, 2007). There are, however, certain points of connection and similarities between the varieties of TOC that have been developed. Vogel (2012b:2), for example, explains that the development of a TOC is based on deliberations among the members of a change project team about, inter alia:

- The **context** of the initiative (including social, political and environmental conditions) and the current state of the problem/issue the change project is addressing, as well as the actors able to influence change;
- The **long–term change** that the initiative seeks to support (and for whose ultimate benefit);
- The **sequence of events** (either anticipated or required) expected to lead to the desired long-term outcome/s; and
- The **assumptions** about how these changes might happen, and the contextual conditions that may affect whether the activities and outputs are appropriate for influencing the desired changes in this context.

This approach starts with an analysis of the context (a baseline of the situation), the issue(s) needing to be addressed, and an identification of the drivers (actors, networks, stakeholders)

that are or can become involved in the project. This first step provides the justification for the TOC to be developed, and enables the identification of the landscape which the stakeholders will be navigating (Sullivan & Stewart, 2006). The next step is for the project team to state the desired long-term change to be accomplished by the initiative. This, Vogel (2012b:12) argues, is 'intended to provide conceptual clarity about the realistic long-term impact to guide the project team'. It helps to articulate how the baseline situation will be changed. Thirdly, with the long-term vision in mind, the project team will express the change process as a series of events and identify the different short and medium-term changes needed. This will enable the determination of how shifts in knowledge, attitude and skills will lead to the intended change in practices or policies (2012b:12). In this exercise, it is crucial to identify the outcome indicators that the TOC will be measured against, as well as the target actors and a timeline of how/when the shift is estimated to occur (Judge & Bauld, 2001). The fourth and maybe most important step, requires that the project team explicitly state the assumptions underlying the project. Assumptions are understood as 'the values, beliefs, norms and ideological perspectives, both personal and professional, that inform the interpretations that teams and stakeholders bring to bear on a programme' (Vogel, 2012a:26). Due to their nature, making assumptions explicit is difficult. But doing so should improve the way the TOC is articulated (Gambone et al., 2001).

The capacity for implementing a change project is another crucial aspect. According to Vogel (2012b) the development of a capacity for outlining a TOC for a given initiative within an organisation or group of individuals will allow them to better understand and respond to an issue. In the context of this article, this relates to the capacity of the ESD-related change project teams or coordinators at particular teacher education institutions to successfully put into practice the wider vision set by the ESSA programme. The capacity development of teacher educators should aim at strengthening their professional capacity in terms of: (a) developing and articulating a change project in their institutions, and (b) developing their understanding of the concept of ESD and its practical in-class application.

Theory of education for sustainable human development

In reviewing the concepts of functionings, capabilities and agency, as originally outlined by Sen (1989), Landorf, Doscher and Rocco (2008) offer a framework for assessing ESD-related learning outcomes, teaching practices, curricula, and knowledge and skills acquisition. They re-define ESD as education for sustainable *human* development (ESHD) in order to emphasise that education should focus on enhancing well-being, based on a practice of democratic dialogue, and forms of learning that include local cultural and social realities. Accordingly, the educator is responsible for evaluating the contextual circumstances that will impact the students' well-being, and for providing a form of teaching that enables their students to understand their own capabilities. It requires that teachers be finely tuned to their students' needs, and create a space for them to understand and become who they are. The 'democratic deliberation' between the teacher and the students allows them 'to identify basic capabilities and culturally valued functionings in the communities in which they practice' (2008:232) – in short, to create agency. The TESHD thus enables a link between expected ESD skills and the formation of capabilities and learning outcomes, through the articulation of improved pedagogy, curriculum and assessment frameworks.

There is a wide body of literature on how ESD is meant to achieve its aims. Hoffman (2006) articulates how the four 'pillars of learning', as defined by the International Commission on Education for the Twenty-first Century (Delors *et al.*, 1996), provide connecting points with Sen's vision to move towards achieved functionings. The four pillars (learning to know, learning to be, learning to live together, and learning to do) provide a parallel to Sen's concepts of reasonings, agency, potential through social capital and achieved functionings. Landorf *et al.* (2008) articulate this in terms of relevant pedagogy, curriculum and assessment in the context of educational institutions:

- *Pedagogy* for sustainable human development is centered on democratic dialogue. The educator facilitates a democratic dialogue with all learners with the aim of making them understand its significance: 'that freedom of choice has value in and of itself, regardless of results' (2008:233).
- *Curriculum* for sustainable human development goes beyond environmental education while focusing on 'locally determined basic capabilities' (2008:232). The educator's role is to guarantee that the curriculum is built through a process of democratic dialogue, where learners and community stakeholders 'address what students must know and [are] able to do in order to achieve valued functionings' (2008:232).
- *Assessment* for sustainable human development is closely associated with democratic dialogue. 'From the beginning of the year,' explain the authors, 'the educator and students should together assess the students' capabilities, and what they must know and learn in order to achieve locally valued functionings.' Examination 'is a recursive process, in which continuous monitoring of progress towards mutually agreed upon capabilities becomes an intrinsic element for both the educator and her students' (2008:233).

Table 1 summarises how ESD, Sen's capability approach, and education for sustainable human development relate to each other.

Table 1. How the 'four pillars of learning' relate to education for sustainable human development through the frame provided by the human capability approach

The 'four pillars of learning' and associated requirements:	The capability approach covers:	Education for sustainable human development covers it through:
Learning to know Recognising the challenge	Reasoning	Relevant pedagogy: towards locally determined capabilities
Learning to be Recognising the indivisibility of human dignity	Agency	Pedagogy based on democratic dialogue and self-agency
Learning to live together Recognising collective responsibility and constructive partnership	Potential through social capital	Building consensus on the basis of democratic discussion of values, goals, and priorities
Learning to do Acting with determination	Basic capability or achieved functionings	Learning about oneself and identifying personal preferences

Source: Adapted from Hoffman (2006) and Landorf *et al.* (2008).

During the field research, the TESDH was applied in two ways. First, it offered a guide to observe how different teachers involved with an ESD-related change project bring ESD into their practice. Second, it helped to understand what learning outcomes are to be expected in learners who are exposed to ESD pedagogies. The TESDH's strength lies in its ability to link relevant pedagogy with agency in learners – agency being a core element of ESD in general, and the ESSA programme in particular.

Theory of transformative learning

The field of education, and especially teaching and learning in the context of sustainability, has brought considerable attention to the theory of transformative learning. With its emphasis on learning processes and outcomes, TTL has enabled a re-framing of the role of education in relation to sustainability. As argued by Wals (2010) and Sterling (2005, 2011) the pluralistic society we live in (characterised by a wide range of values, interests and actors, along with the complex nature of sustainability issues) requires a way of learning that addresses divergent interests. Described as a pluralism of thoughts, TTL places emphasis on a critical, problem-based and reflective practice of education (Thomas, 2009). It enables: 'Education that fosters critically reflective thought, imaginative problem solving. The discourse is learner-centered, participatory, and interactive. It involves, group deliberation and group problem solving' (Mezirow, 2000:10).

For the TTL, sustainability is not a vision that education should strive for. Instead, and echoing a notion of critical ESD developed by Vare and Scott (2007), it becomes the state that emerges through transformative learning processes (Wals & Jickling, 2002; Wals & Corcoran, 2006). This transformative learning in the context of sustainability is a form of learning that enables alternative and new kinds of thinking and solutions that are 'co-created [and] co-owned by more reflexive citizens, living in a more reflexive and resilient society' (Wals, 2007: 42).

The TTL focuses on the processes that facilitate a collaborative reflection of the learners involved. It assumes that the reflexive interaction with heterogeneous members of a group allows the learners to mirror their own positions and mind-sets with those of others in the group. Wals (2007) stresses how a carefully balanced collaborative setting enables what he terms the 'deconstruction' (or de-framing) of individual assumptions and ideas which are then further challenged and assimilated with other ideas in a process of co-creation. For the TTL, this process of frame deconstruction is assumed to occur in, but not be limited to, group deliberation and social interactions. Not all participatory learning processes automatically result in a transformed understanding of an issue; but the transformed understanding that on occasion does occur, especially within the context of sustainability and through group processes, has been qualified as 'transformative social learning' (Wals, 2010). Essentially, this refers to the notion that a pluralistic and heterogeneous group will be able to identify new ways of approaching a problem as the group's internal diversity will help with 'switching back and forth' between different mind-sets and understandings of an issue.

Wals and Corcoran (2007) identified eight modalities that, integrated into higher education settings, foster autonomous thinking and an inclination toward systemic change among students

and educators alike (see Table 2). By applying the TTL in teacher education institutions in Botswana, we wished to determine whether and how these modalities manifest themselves in the different ESD-related change projects.

Table 2. Eight modalities of transformative learning in higher education

Modalities	Description	Example
1. Total immersion	Fostering a direct experience with a real-world phenomenon.	Observing and monitoring sustainability impacts. Managing a specific issue.
2. Diversity in learning styles	Being sensitive to the variety of learning styles, and preferences that can be found in a single group.	Offering a variety of didactic approaches. Reflecting on the learning processes with learners.
3. Active participation	Developing discourse and ownership by utilising learners' knowledge and ideas.	Soliciting the learners' own ideas, conceptions and feelings.
4. The value of valuing	Exposing the learners to alternative ways of knowing and valuing through self-confrontation.	Giving learners opportunities to express their own values. Creating a safe and open learning environment.
5. Balancing the far and near	Developing empowerment by showing that remote issues have local expressions which one can influence.	Relating issues of biodiversity or sustainability to last night's dinner.
6. A case study approach	Digging for meaning by studying an issue in-depth and looking for transferability to other areas.	Assigning different people to explore different angles of a particular theme and bringing the different angles together.
7. Social dimension of learning	Mirroring learners' ideas, experiences and feelings with those of others, through social interaction.	Taking time for discussions and exchange. Addressing controversy. Stimulating flexibility and open-mindedness.
8. Learning for action	Making the development of action and action competences an integral part of the learning process.	Allowing learners to develop their own course of action and to follow through with it. Studying examples of action-taking elsewhere.

Source: Wals and Corcoran (2007)

Discussion of the framework

In the above discussion, we have shown how each of the three theories have their own explanatory power. However, each of them remains partial in its ability to grasp the whole, especially when evaluating such a complex endeavor as an ESD-related change project in a teacher education institution. One of the characterising principles of ESD is that it is holistic in that there is an intricate dynamic between educational content and pedagogical method, as exemplified by the TESDH and the TTL. It also pertains to the close association between ESD's

substance and the manner in which ESD is being implemented through change projects, which is the major objective of the TOC. Concentrating on one theory while excluding one or two others violates this characteristic.

The three theoretical constructs provide a strong and dynamic frame to review what goes on in institutions that have decided to adopt ESD in their curriculum and teaching practices. Firstly, the TOC enables the identification of the different elements to facilitate the implementation of an initiative or project. It helps to identify the limiting or helping factors that accompany the change projects in their current state, such as the assumptions of the stakeholders involved, the dissonance in understanding different concepts, and the wider institutional context in which the change project is being developed. ESD implies a type of learning that equips learners to be able to navigate increasingly uncertain situations, to connect with real life challenges – a type of learning that is empowering, reflexive and critical (Lupele & Lotz-Sistka, 2012). To reflect this, the TESHD and the TTL together allow for the articulation of learning processes that enable the development of relevant knowledge, skills and competences to connect and deal with life's challenges. With the help of the TESHD, one can identify how student-teachers' and teacher-educators' values are formulated and reflected in the context of the classroom. It also provides a frame for understanding how dialogue among learners can make learning and teaching more culturally relevant and democratic. Individually, the two lenses identify the features of innovative pedagogies and, when combined, help focus on agency or action-oriented learning, which is associated with a more reflexive and value-based approach to teaching and learning.

Through the assembly of its different elements, the framework is sensitive to the context in which it is being used. It is wide enough in its approach to deal with the complexity of the situations under study. At the same time, its individual components provide enough specificity to identify unique conditions or characteristics within teacher education institutions and compare ESD-related change project implementation in different contexts. Importantly, the framework allows this through its ability to cover two critical sets of ESD project implementation variable: (a) its sensitivity to individual and group key capacities (through the TOC, TESHD and the TTL); and (b) key contextual factors (through the TOC) supporting or hindering the implementation and support of ESD. Figure 1 illustrates how the conceptual framework – and the different themes it addresses – guided the gathering and structuring of data among teacher-educators, administrators and student-teachers in Botswana.

This framework and its two emergent dimensions were used as framing for the development of the methodology, the generation of the data, and the subsequent analysis of the two teacher education institutions considered in this article.

Figure 1. Assessing curriculum change projects with an 'evaluative' framework
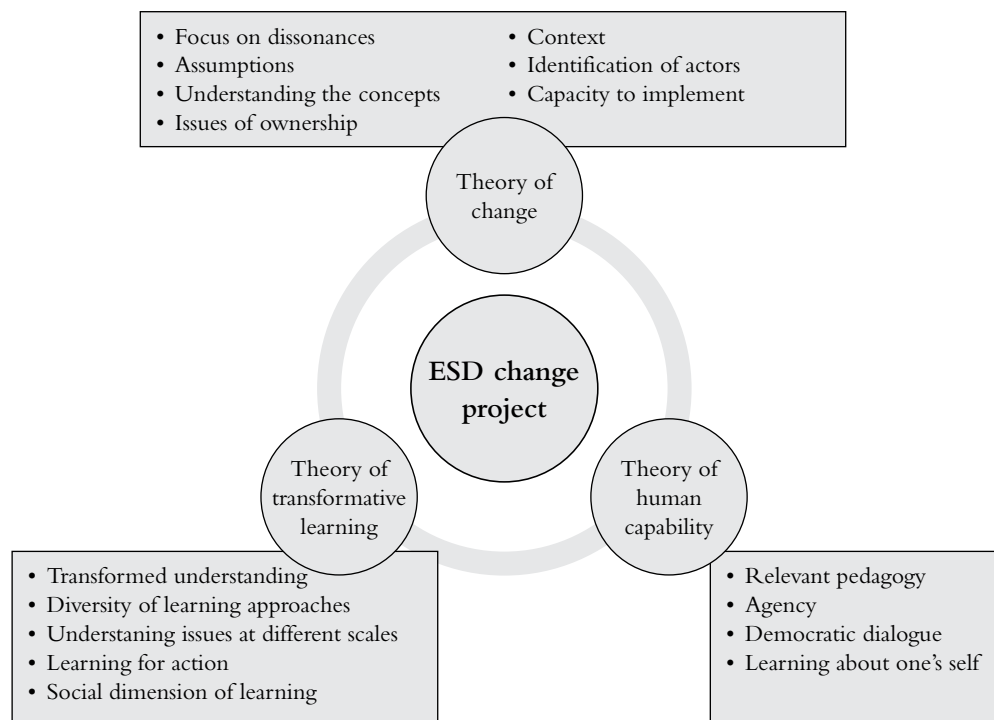
The Research

With an earlier version of the framework developed above, Schrage (2015) undertook a qualitative study to determine whether and how teacher education institutions in Botswana were implementing, or had implemented, the change projects they had decided to undertake as a consequence of their having participated in the ESSA training workshops during 2013 and 2014. Data were generated in six teacher education institutions through individual and focus group interviews with teacher-educators, student-teachers and heads of institutions. These were complemented with document analysis and field observations. The different research techniques allowed for triangulation of the data. They assisted in probing the same phenomenon from different angles, and helped to obtain an understanding of its complexity.

This article focuses on the results in two out of the six teacher training institutions. They are identified as institution A and institution B. At the time of study (March 2015), each institution had articulated its own change project. The two change project coordinators in institution A aimed at infusing ESD through the design and development of the curriculum, educational materials and learning assessment tools. The change project in institution B was specifically targeting curriculum innovation and development of instructional materials related to in-class teaching practice.

Table 3 lists the different methods used to generate data in the two selected institutions.

Table 3. Summary of the data gathering and analysis process

Institution	Data gathering & capturing tool	Data source	Data familiarisation	Data analysis
Institution A	Interviews	Two change project coordinators	Verbatim transcription and typing of notes	Thematisation of data
	Focus groups	Third year students Second year students	Typing of notes and extraction of quotes and segments of text from different sources	Data reduction
	Documents	Change project reports Institutional policy documents Student assessments	Verbatim transcription and typing of notes	Interpretation
	Field notes	About change project coordination team and project	Typing of notes	Triangulation with other sources
Institution B	Focus groups	Second year students Change project coordination team	Typing of notes and extraction of quotes and segments of text from different sources	
	Documents	Change project reports Institutional policy documents Student assessments	Verbatim transcription and typing of notes	
	Field notes	About change project coordination team and project in both institutions	Typing of notes	

Application of the Framework: Results

For the two teacher education institutions considered for this article, the findings are summarised in Table 4.

The combination of the three theoretical lenses made it possible to comprehend the extent to which the change projects contributed to embedding or infusing ESD in the training of student-teachers. The framework helped to identify a wide array of change project team factors supporting or hindering ESD infusion. Such factors included the teams' use of teaching methods, learning support materials, assessment, curriculum and understanding of ESD. The framework also helped to identify a group of factors external to the change project team that have been shown to impact how ESD teaching and learning practices were being mainstreamed in teacher education institutions in Botswana.

Table 4. Summary of research findings

Institution/ Framework	Theory of change	Theory of education for sustainable human development	Theory of transformative learning
Institution A (university) change project: 'Infusing ESD in the curriculum of teacher trainers'	**Context:** Favourable but limited for project implementation. **Capacity to implement:** Strong understanding of concept of ESD in theory and practice. Strong ownership of project at individual level. Ability to adapt project to institutional reality. **Assumptions:** Assumptions about project articulation explored and some addressed. **Long-term change:** Articulation of intended long-term changes and identification of actors to implement that goal.	**Pedagogy**: Integrated notion of 'relevant pedagogy' and focus on pedagogy for 'agency'. **Curriculum:** Infusion through changed learning outcomes, evaluation & content. **Assessment**: Change in assessment, reflecting notion of democratic debate and agency between student and teacher.	**Detected modalities:** Through diversity of learning approaches, exploration of issues at multiple scales, case studies, and exploration of the social dimension of learning.
Institution B (teacher education college) change project: 'Curriculum innovation and material development'	**Context:** Administrative and institutional context is supportive to change project implementation. Multiple stakeholders involved in project. **Capacity to implement:** Low. Limited understanding of concept of ESD in theory and practice. Some dissonances between members. Low ownership on behalf of project team. **Assumptions:** Several assumptions pertaining to ability to effect change with regards to set goal. **Long-term change:** Weak articulation of intended long-term change.	**Pedagogy:** Little or no change observed. **Curriculum:** Creation of booklet compiling in-class activities; limited focus on developing 'agency'. **Assessment**: No change in assessment.	**Detected modalities:** Focus on diversity of learning approaches.

In the following section, we discuss the findings related to the teams' and individuals' capacities to introduce change in their home institutions and to the context in which this implementation took place. In both cases, significant differences showed up between the two teacher education institutions.

Analysis and Discussion

The data and following analysis has been organised following the two sets of critical variables emerging from the combination of the framework's theoretical lenses, namely, the variables relating to individual and group capacity, and those associated with context.

Set 1: Individual and group capacity variables

Firstly, the extent of the 'consonance' or 'dissonance' between the team members seemed to have a strong impact on the team's capacity to infuse ESD. At institution B, there were clear differences of opinion among the change project team members. Two respondents explained that ESD learning should enable the creation of 'engaged citizens' with a sense of agency. Other respondents expressed the idea that ESD should include the notion of life-long learning, or should aim towards a 'cleaner environment'. In the absence of consensus, it is difficult to see how the project team could effectively proceed with the change process. Institution A's change project did not show such dissonance. Unlike institution B, where a variety of stakeholders were brought together around the change project, the project coordinators in institution A did not establish a wider project committee. Instead, they themselves initiated and led the project implementation. Thus they reduced the possibility for dissonance or misunderstanding.

Secondly, the TOC explains that having a long-term goal, developing a plan of implementation and assigning different tasks to the team members develops ownership of the project while building agency among the different members. In this regard, the level of ownership differed between the two teams. At institution B, it appeared that the change project group had not articulated a long-term vision. This had a negative influence on the members' perception of the purpose of the change project, in terms of ESD pedagogy and content development. The data showed that, due to the absence of an internally developed common vision, the group was working towards meeting the perceived expectations of external actors; such as those of the Ministry of Education or ESSA workshop facilitators. In contrast, in interviews with the change project coordinators at institution A, they expressed a long-term vision for their change project and identified several actors and strategies to produce their desired outcomes, thus showing a clear sense of agency and ownership.

Thirdly, and perhaps most importantly, according to Vogel (2012a) the ability of the change project team to implement change relates to their ability to adapt to and adopt new forms of knowledge for their project, in other words, their 'capacity to learn'. With respect to our research, it is the capacity of the change project coordinators to comprehend the concept of ESD and to translate this understanding into learning outcomes, skills, pedagogy, curriculum change, assessment and content development. The TTL and TESHD provide a framework to understand ESD in this regard. The change project coordinators at institution A expressed a wider set of themes (ten) related to the two theoretical frames (see Figure 1) than those at institution B (three).

The extent to which ESD was infused in the two institutions seemed to depend on the ability of the project coordinators to articulate a comprehensive understanding of the ESD concept

– what the TOC describes as 'conceptual clarity'. The project coordinators at institution A had engaged with the concept of ESD in higher education for many years and were therefore well-versed in its articulation and implementation. The project coordination team at institution B had been exposed to ESD and its many facets during the ESSA workshops (in the previous months) for the very first time; at the time of research they had not engaged much with using the ESD concepts in their daily practice.

The capacity of change project coordinators to implement the desired change in their institution does not only depend on their inherent or acquired capacity to learn; as is presented below, it is also facilitated or inhibited by the context in which they and their change projects are situated.

Set 2: Contextual variables
The TOC explains that the wider context in which the change is occurring will inherently affect project articulation. Our framework enabled identification of the contextual elements affecting the way the change projects were articulated, developed and implemented, namely: the organisational set-up of the teacher education institutions; the institutional environment provided by the Ministry of Education and Skills Development; and the wider policy environment in which the projects were situated.

The data highlighted how the institutional and administrative structure in which the different change projects took place affected their development. At Institution B, the change project was situated under the principal's office. It involved heads of department as well as administrative staff. The involvement of such a variety of staff could be thought to encourage and facilitate the introduction of changes in the curriculum. However, this was not the case. The organisational structure of the institution seems to confer much authority and control to the principal; this places limits on the space that teacher educators have or perceive to have in taking initiatives and making their own decisions about their work practices. The change project coordinators expressed the opinion that their environment was constricting them in the development of their change projects.

By comparison, the administrative context of institution A was quite different. According to formal university rules, a proposal for changing teaching and learning processes is required to receive approval from a wide list of different actors: the department board, the faculty board, the advisory board, the school of graduate studies board, the academic planning committee and the senate. Despite (and perhaps because of) this complexity, such an administrative structure might provide for greater autonomy and agency among the teacher educators. Interviews with change project coordinators at institution A highlighted how they developed their projects in such a way to avoid what one of the change project coordinators called 'administrative red tape'. This institutional environment and the capacity of the change project coordinator to adapt accordingly likely affected the way in which the project itself was articulated.

The framework developed for this paper also revealed that the ministry's perceptions of ESD affected the formulation and development of the change project. At institution B, for example, various project coordinators noted that an official of the Ministry of Education had influenced the articulation of their change project. Moreover, field notes and interviews showed how

funding opportunities for teacher education institutions were dependent on the way in which they framed their institutional change project.

Another contextual element that emerged from the interviews is the 1994 document developed by the National Education Commission. This commission introduced, for the first time, the necessity to teach and infuse school curricula with the concept of environmental education (Government of Botswana, 1994). Both change project coordinators at institution A referred to this document to justify their own approach in their change project. No other or more recent policy or document was mentioned.

Conclusion: Towards a Framework to Support ESD Infusion

We conclude that the theoretical framework presented and 'tested' in this article matches the multidimensional nature of ESD. The TESHD together with the TTL helped develop an understanding of the ways in which ESD content and methods are being articulated in different teacher education institutions in Botswana, and how they translate in terms of transformative content, pedagogy and assessment. In addition, the framework (including the TOC) proved to be flexible and sensitive enough to discern the different administrative and institutional conditions in which the change projects were situated. At the same time, the framework's complexity proved to be both a strength and a weakness. Combining the three theoretical concepts is a way to cast a large net for understanding how ESD infusion can be fostered; however, this very combination brings together such a variety of themes and elements that the framework is cumbersome in its use. Enhancing the framework's analytical precision and power for identifying and assessing ESD practice and infusion would necessitate its further specification and operationalisation, as well as the actual testing thereof. It would also require more pertinent data collection methods, as well as a more detailed and standardised protocol for analysing and characterising the data. Such refinements are likely to provide a more profound analysis and more meaningful results. This would be a step towards addressing a lack of support currently plaguing the wider implementation of ESD in formal educational settings.

This framework (with its potential future refinements) provides insight into critical aspects, factors and conditions that impact ESD infusion. It is anticipated that it can be used for guidance and planning by educational administrators and other decision-makers involved in ESD-related/inspired change projects, programmes and policies.

Notes on the Contributors

Jesse Schrage is a Bachelors- and Masters-level course coordinator and educator at the Centre for Environment and Development Studies at Uppsala University. Jesse works to embed transformative, collaborative and trans-disciplinary approaches to teaching and learning in higher education. Email: jesse.schrage@csduppsala.uu.se

Frans Lenglet is an educator and evaluator. Between 2008 and 2015, he was the director of the Swedish International Centre of Education for Sustainable Development (SWEDESD) at Uppsala University, Visby, Sweden. Email: frans@thelenglets.com

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Change Project–Based Learning in Teacher Education in Botswana

Mphemelang Joseph Ketlhoilwe & Nthalivi Silo,
University of Botswana, Botswana

Abstract

Environmental education (EE) and education for sustainable development (ESD) pedagogies are intricate, and to enhance learning, teacher education has to be innovative in teaching approach. This article investigates how the change project approach enhances project-based learning in practice. The investigation is based on teacher education programmes in Botswana teacher education institutions (colleges of education) where a few teacher educators were introduced to Education for Strong Sustainability and Agency (ESSA) change projects. Preliminary results of the change projects' evaluation indicate that change project ideas were enthusiastically accepted by teacher-educators and students across the teacher education colleges in Botswana. This research is a follow-up to change project implementation and its outcomes in two teacher education institutions in Botswana. It is framed within a project-based learning approach in teacher education. Data were generated through site visit observations and interviews with teacher-educators and student-teachers. The outcome indicated the viability of project-based learning (PBL) as an appropriate approach to transformative pedagogies for ESD in teacher education. The PBL approach is recommended for teacher training education to facilitate strong sustainability and agency among student-teachers.

Key words: project-based learning, change project, ESD, environmental education, teacher education.

Introduction

Environmental and sustainability education is an important global trend that could be promoted through teacher education and partnerships in this era of environmental challenges. The idea of an ESD change project has been born out of a call for reorienting education towards sustainability. In Botswana, one way of responding to such a call was to engage in ESD change projects in teacher education institutions to promote environmental and sustainability education. In this research, we investigate how the change projects implemented by educators who participated in the Swedish Education for Strong Sustainability and Agency (ESSA) enhances the project-based learning (PBL) approach (Lee, Blackwell, Drake & Moran, 2014; Krajcik & Blumenfeld, 2006; Markham, Larmer & Ravitz, 2003). The main object was to get insight into how they used the course concepts of strong sustainability and agency to identify, plan, design and create projects as part of capacity-building in their institutions, and how this

linked to the curriculum. The educators facilitated learner-centered activities in these projects, mobilising resources as they reflected on the learning outcomes from the change projects.

50 teacher educators from 28 teacher education institutions in the SADC region were exposed to the ESSA course, whose objectives were to support professional development and to enhance institutional capacity to initiate and support change in the field of ESD pedagogies. Change projects were developed out of, and were directly linked to, institutional situations. The projects were structured into phases. During the initial phase, institutions completed an institutional audit and identified an aspect of the institution's issues to focus on. The audit provided an opportunity to deepen insights and clarify what needed to change in the institution through the change project. Course participants were expected to work closely with colleagues and other interest groups linked to change projects, and share how insights gained from the course could enhance the work done in environmental education. Furthermore, they were expected to ensure that the change project was both relevant and innovative in sustainability practices in the institutional work context. During this phase, they were also expected to ensure that their colleagues were able to work closely with the development and implementation of the change project by linking it to the curriculum. Throughout this phase of the project, there were coordinators and mentors from the Teacher Education Department of the Ministry of Education and the University of Botswana, who were available to provide support.

This article focuses on the following key objectives:

- ESD change project initiatives implemented in the institutions;
- How other stakeholders support the change projects;
- How change actions feed into the curriculum, teaching and learning in the institutions; and
- How the change projects bring in the whole institution to participate.

Ideally, a change project should be part of participants' work, and implementation must be carried out within the institutions' work plans and budget. The change project approach is meant to respond to the needs and opportunities within the broader institutional context. It should respond to participants' professional development, the institutions' priorities, and to the field of ESD within the institution. Project-based learning (PBL) offers an inquiry-based approach that provides opportunities to transform and reform learning experiences characterised by engaging learners in contextually complex projects (Lee *et al.*, 2014; Krajcik & Blumenfeld, 2006; Markham *et al.*, 2003). PBL is an ideal tool to analyse the outcomes of the institutional change projects.

Conceptualising Project-Based Learning in ESD

The concept of PBL in ESD in teacher education calls for both epistemological orientation and pedagogical innovations to promote sustainability and agency. PBL has much to offer in teacher education settings through its emphasis on learning through working on projects in teams (Nation, 2008). It is the challenge for teacher educators to facilitate these processes. PBL could

be introduced to teacher education institutions to promote sustainability education through change projects (Han & Bhattacharya, 2001:12).

The Buck Institute for Education (2015) describes PBL as a teaching approach that engages students in learning essential knowledge and life-enhancing skills structured around complex, authentic questions and carefully designed projects. For this reason, PBL requires time, thought, and careful planning to be of value. Furthermore, environmental project-based learning provides an ideal opportunity for interdisciplinary learning. 'A project is meaningful if it fulfills two criteria. First, students must perceive the work as personally meaningful, as a task that matters and that they want to do well. Second, a meaningful project fulfills an educational purpose' (Larmer & Mergendoller, 2010:2).

PBL approaches enable educators to deploy a constructivist approach in teaching ESD/EE. Constructionism (Papert, 1991) is both a theory of learning and a strategy for education. It builds on 'constructivist' theories, asserting that knowledge is not simply transmitted from teacher to student, but actively constructed in the mind of the learner. Learners are not required to get ideas from the facilitators, but to create ideas drawing on the project. Moreover, constructionism suggests that new ideas are most likely to be created when learners are actively engaged in building some types of external artefacts that they can reflect upon and share with others. In this study, artefacts are the institutional change projects.

Han and Bhattacharya (2001) and Papert (1991) differentiated between constructivism and constructionism. They posit that constructivism expresses the theory that knowledge is built by the learner, not supplied by the teacher; while constructionism 'expresses the further idea that happens especially felicitously when the learner is engaged in the construction of something external or at least sharable' (Papert, 1991:3). They further agree that constructionism supports the constructivist viewpoint that the learner is an active builder of knowledge (Han & Bhattacharya, 2001). In this research, the project ideas were the creations of the participants, linking sustainability to projects aiming to solve an environmental issue in their institutions. Drawing on Han and Bhattacharya (2001) generally, three phases can be suggested in conducting PBL. These are: planning, implementation (creation), and reflection and follow-up (see Figure 1).

Figure 1. Framework of project–based learning
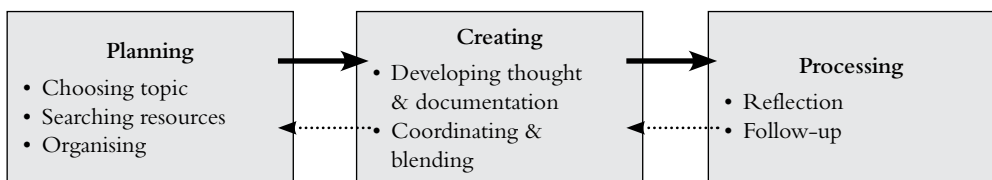
Source: Han and Bhattacharya (2001)

In the planning phase, the student–teachers (with the assistance of the teacher–educator) choose a project, locate the required resources and organise the collaborative work. Through these activities, they identify a topic, gather relevant information and generate a potential solution.

In the second phase, the students engage in activities such as development, documentation, coordination, contributions and presentation. Students are also expected to build a product that can be shared with others during this second phase. The third phase of the project includes reflection and follow-up on the projects. The students share their project outcomes in a small group or with the entire class, obtain feedback, and reflect on the learning process and the project (Han & Bhattacharya, 2001).

Project-based learning is closely related to problem-based learning, especially in the institutional ESD change projects under this study, where the starting point was for teacher-educators and student-teachers to agree on an institutional issue of concern. The initial planning stage for the project was to make a significant change in college practices that would promote sustainability of the resources in relation to the identified issue. This could not be separated from the curriculum, as student-teachers were involved to make it relevant to their academic life. The project was expected to create links between theory and practice.

PBL as a strategy for strong sustainability and agency
ESD pedagogy should emphasise an interdisciplinary, culturally relevant, student-centered, practice-based approach on shared and group learning for problem-solving and agency (Wade & Parker, 2008). The focus of this paper is to follow-up on the change project implementation and its outcome as an institutional ESD pedagogical approach. The PBL approach explained above provides a focal point in the form of strong sustainability and agency. While the notion of strong sustainability has been quite ambiguous in literature, Ott, Muraca, and Baatz (2011:15) posit that strong sustainability aims at identifying criteria that distinguish non-sustainable from sustainable pathways on the grounds of a wider consideration of arguments for natural resource use than merely economic ones. This, they argue can be achieved through specifying the proper scope of the discourse by setting up a framework of fields of action and application by human agents who have to perform as a 'rational corrective' to clarify the diffuse discourse on sustainable development taking place in society. Implied within this definition, the notion of strong sustainability is about maintaining minimum critical thresholds of natural capital over time (Pelenc, Lompo, Ballet & Dubois, 2013). The idea of 'strong sustainability' encompasses issues of intra- and inter-generational distributive justice regarding natural resources (Ott & Döring, 2008), making reference to the importance of teacher-educator/student-teacher collaboration in these projects.

Strong sustainability encompasses what could be regarded as a good life (that is, life that is rich and flourishing). The key principles of strong sustainability have been identified as: resilience, sufficiency and efficiency (Ott *et al.*, 2011). Strong sustainability could be promoted through understanding planetary boundaries and ecosystem services. In these projects, strong sustainability would be seen through practical demonstration of resilience, resourcefulness and participation by teacher-educators and student-teachers in the project.

The concept of a human 'agent' implies acknowledging responsibility of human action as defined by Becker (2006). For the purpose of this study, the notion of 'collective agency' is considered, in which a community of human agents make sustainable choices in order to maintain the conditions required for human life on earth, while ensuring social sustainability

by taking into account the well-being and values of other individuals (Pelenc *et al.*, 2013:88). Collective agency has to emerge through a learning process based on interactions between people (Pahl-Wostl, 2006), where every individual member of the teacher colleges under this research pursues the perception of the collective-good, to bring about changes through these projects (Ibrahim, 2008:67). Agency, viewed this way, provides for individual freedom of choice. In this article, strong sustainability encompasses the ability – enhanced by project-based learning – to act willingly and independently as a means to promote sustainable development. It is hoped that the project may yield some personal attributes that would contribute to strong sustainability beyond teacher training and the project's lifespan.

Research Methods

The overall goal of the study was to follow up on change projects implemented at teacher education institutions in Botswana, and assess their progress as far as strong sustainability and agency are concerned. The ongoing change projects investigated for this paper were a grey water system at Francistown College of Education (FCE), and used/waste oil collection at Molepolole College of Education (MCE).

Study participants and methods

Out of the five institutions that were involved in change projects, two were selected to generate data for this study. These two were selected purposefully, since they experienced fewer implementation hurdles and were in advanced stages of project implementation. Both educators and student-teachers were fully involved in project planning and implementation. This is a qualitative research design based on interview and observation techniques as sources of data. The preferred techniques were mainly hands-on.

Interviews
Interviews were conducted amongst teacher-educators and focus group interviews with completing student-teachers at the teacher education institutions where there were ESD/EE change projects. We developed an interview guide for the teacher-educators. The guide was specific enough to adequately cover the evaluation questions and extract the teacher-educators' involvement with the change project. The student-teachers were interviewed in order to understand their participatory role in the change projects through focus groups; the advantage being that they provided collective views, as well as the implications behind those views (Gill, Stewart, Treasure & Chadwick, 2008). The researchers used an observation protocol (rubric/check list), research notes and insights from debriefing each other to produce the necessary triangulation for reasonable conclusions.

Observations
These were done at project sites by the researchers and the Teacher Training & Development Department of the Ministry of Education, who also provided support through capacity-building workshops, and payed regular visits to determine whether the acquired knowledge

and skills from the ESSA course and change projects were applied in practice. The criteria for the observations included processes followed during college-based workshops, such as practical application of skills acquired from the ESSA training, and student participation in change projects.

Data analysis
This included a review of data generated, transcribing recorded information, determining significant statements, clustering statements, and interpreting data and clustered themes as sources of information (Miles & Huberman, 1994). Analysis also included observable actions in practical projects at both institutions.

Drawing on the PBL model presented in Figure 1, Figure 2 (see below under *Discussion*) provides the framework for analysis, highlighting elements of strong sustainability and agency in the change projects as reflected in how educators and students participated in the planning, creation and reflection process.

Institutional Change Projects

In this section, we report results from the two institutions, based on the research objectives and the two phases of the projects. The main objective of this study was to analyse the progress and impact of institutional change projects' implementation. More specifically, the purpose was to derive information about change project implementation, support from other stakeholders (specifically the Ministry of Education), teaching and learning links, and stakeholder and student participation in the project. In the first phase, ESD capacity-building workshops were undertaken for staff and student-teachers. These workshops were conducted with the support of, and in collaboration with, the University of Botswana in which the authors were support agents. The second phase entailed the material component of the project. The results of the two projects are presented separately.

Francistown College of Education (FCE)
The change project at the FCE was on grey water recycling and its integration into the curriculum, across disciplines. The project involved collecting water from student hostels and kitchens, and required material sourced through the college and partners.

The FCE is an institution with an average enrolment of 150 students, almost all of whom are accommodated in the college. A lot of water is used in the students' hostels and kitchens; all of which goes to waste. This is what generated the project idea of collecting and recycling water for gardening and landscaping purposes. The college incurs high water bills as a result of this high water usage; the project's objectives were therefore to enhance the mainstreaming of ESD into all the subjects in the curriculum, and to keep the college environment green.

Capacity-building workshops
The teacher educator who participated in the ESSA course deployed the cascading model to build capacity among educators and students. To facilitate this process, three colleagues were

coopted to form a committee to drive the change project activities. As a committee, they ran ESD workshops for heads of departments (HODs), and the institution's management (whose principal was very enthusiastic), educators, support staff and student-teachers. The focus of the workshops was to build the capacity of the college community in terms of their understanding of ESD in the context of their day-to-day activities, work, teaching and learning processes. However, other colleagues, particularly from Religious and Special Education, indicated that it would be very difficult for them to mainstream the change project ideas into their subject areas, since they perceived ESD concepts to be mainly focusing on practical subjects.

As part of the change project, participants conducted an institutional analysis of how the various subjects could mainstream the change project into their daily teaching and learning activities. Table 1 highlights the various integration modes that were highlighted.

Table 1. Change project integration at Francistown College of Education

	Method / Strategy of change project integration					
	Verbal encouragement	Enforcement of college rules on sanitation	Syllabus content	Infusion	Research Projects	Clubs
Departments / Offices	■					
Principal	■					
Deputy Principal – Academics	■					
Deputy Principals – Administration	■					
Dean of Student Affairs		■				
Agriculture			■			
Art, Craft & Design			■			
Guidance and Counseling			■			
Home Economics					■	
Religious Education			■			
Science			■			
Special Education			■			
Setswana			■			
Social Studies			■			
Mathematics				■		■
Communication & Study Skills				■		
English				■		
Music				■		
Physical Education, Sports & Culture				■		
Foundations of Education				■		
Total no. of staff	**3**	**1**	**9**	**6**	**3**	**1**
Percentage	**15.7**	**5.2**	**47.3**	**31.6**	**15.7**	**5.2**

From the capacity-building workshops, the idea and choice of the change project emerged by collectively assessing the main environmental issue in the college; in this case, the amount of grey water that goes to waste.

Grey water recycling
For the actual material project, the college identified and engaged the services of a voluntary consultant, with the assistance of the Water Utilities Corporation (the main parastatal organisation for supplying water in Botswana), to assess the water quality for irrigation. The college maintenance staff dug the trenches for pipes from the dining hall to the water collection reservoir. The students provided labour for the construction of the stand for a 10 000l reservoir tank, which was built in collaboration with the Bricklaying Department of Shashe Brigade. Shashe Brigade is a government-owned technical artisan institution that offered its construction services for free.

Molepolole College of Education (MCE)
The change project at the MCE focused on the proper disposal of used oil. The college project team, led by the educator who attended the ESSA course, conducted college-based capacity-building workshops similar to the FCE. The main objective of their change project workshops was to educate the college community about a clean environment within the ESD framework.

Capacity-building
After the initial capacity-building interactions with the institution community, the educator started working closely with students and initiated the production of an ESD manual with student–teachers. The manual was meant to support educators and student–teachers in their understanding of ESD, and the activities they could undertake in the teaching and learning processes for mainstreaming the change project approach. Some students actually went further and drew on the change project for their mini project presentations in Science. The college identified 'proper disposal of used oil from the kitchen' as its change project.

Proper disposal of used cooking oil
The institution uses a lot of cooking oil, which is not disposed of appropriately as most of it spills all over the area around the dining hall and is improperly stored in containers adjacent to the dining hall. It is frequently kept there for long periods, which presents an unsightly environment aesthetically, and poses a health hazard as it attracts cockroaches and rodents. In response, they came up with a change project around the safe disposal of oil. The institution consulted with a non-government organisation (NGO), Tshole Trust, which offers a service that collects and disposes of used oil. The NGO provided information on the safe storage and recycling of oil and they also provided a receptor tank into which the used oil could be stored for collection. The college bought several 20l containers, into which the kitchen staff could empty the oil before it is transferred to the larger tank, where it would be collected by Tshole Trust.

Discussion

The findings discussed in this section are related to the research objectives and intended outcomes derived from the change projects in the two institutions. The adapted framework (Han & Bhattacharya, 2001) depicted in Figure 2 acted as a springboard for understanding and synthesising the emerging outcomes of project-based learning in the change projects.

Figure 2. PBL outcomes in the change projects
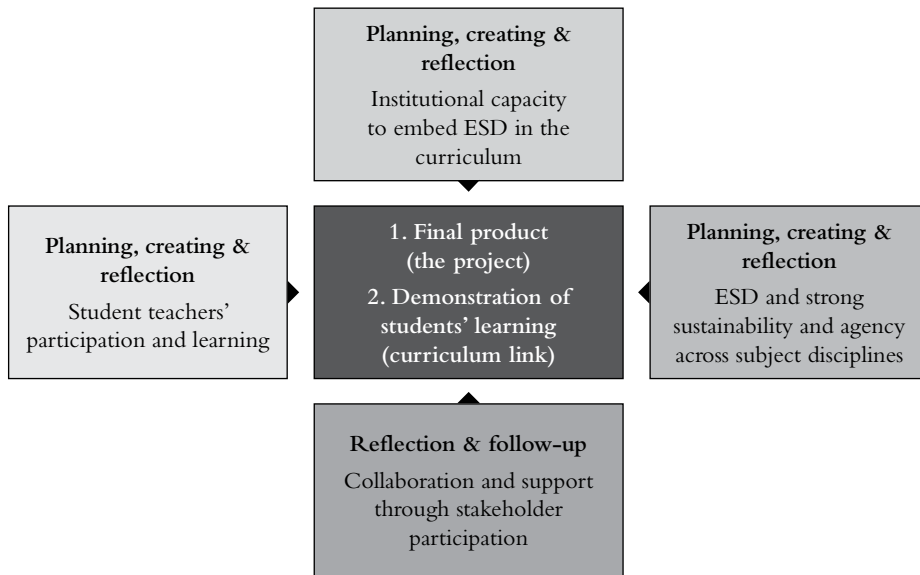
Source: Adapted from Han and Bhattacharya's (2001) framework

The main outcomes are related to the key focus framed within the PBL process components of planning, creating, and reflection (Han & Bhattacharya, 2001). The key emerging research outcomes were: student-teacher participation in the change project, use of change projects for institutional capacity to embed ESD in the curriculum, the importance of collaboration and support through stakeholder participation, and the need to use interdisciplinary collaboration to deepen ESD and strong sustainability and agency across disciplines. All these are directly linked to the key objectives of the research, coming out of the change project and its link to the curriculum (see Figure 2).

Student-teachers' participation and learning
One of the themes of involving people in sustainable development actions is to develop appropriate and genuine participatory approaches and methods that are purposeful (Lotz-Sisitka, 2006). Participatory approaches focus on ESD learning in multiple contexts, including higher education (2006). The change projects approach in this study offered opportunities for such participatory approaches involving real problems with real consequences in these

institutions (Nation, 2008). At the very least, educators wanted to make certain that the change projects engaged students in the planning process and the actual creation of the project in ways that developed agency, ownership and sustainability.

The project activities offered student-teachers a chance to experience the tangible reality of the problems in their institutions, as well as ownership of the project as active participants rather than mere consumers of knowledge. Through their participation in the change projects, student-teachers seemed to be able to gain information, skills and attitudes for a sustainable environment in their colleges; through learning-by-doing and solving problems surrounding sustainability in their context areas, and understanding that ESD is practice-based. This way, change projects not only developed students' critical thinking, research and problem-solving skills, it gave them experience in applying these skills to real world situations (Nation, 2008:109). This is consistent with Genc's (2015) study at Bartin University in Turkey, where he found that prospective student-teachers were motivated by doing short-term project tasks which were found to be adequate in prompting them to make attempts to solve 'real social problems (e.g. garbage, water supply and sewers, abandoned land, erosion, paper recycling' (2015:114).

This was clearly illustrated in the case of the MCE, where students were able to develop their own activities and exercises by designing and developing projects for their course assessment, drawing on the change project, which they further went on to present to their peers. This is illustrated by a student-teacher who said: 'For my Science assignment, I used the project to see how it can be used to solve the problem of pollution caused by oil.'

In the FCE, the students went on to demonstrate the skill of volunteerism by constructing the stand for the reservoir tank. This participation of student-teachers further enhanced their collaboration, cooperation and interaction skills, and group unity, as they had to work closely with each other. By getting involved directly in the project, the MCE students could see the importance of the ESD manual as a means of getting others to understand the relevance of the change project. All of these initiatives are part of what concerns education, and builds resilience and capacity within the socio-ecological challenges they daily encounter – a perspective held by Gough (2006), Sen (2009), Lotz-Sisitka (2010) and Lupele & Lotz-Sisitka (2012), all of whom emphasise that this is the main ESD agenda within the agency and capability orientation. These are all critical skills for the future success (within teacher education structures) of our response to global sustainability issues (Bell, 2010), as observed by the educator at the MCE: 'Students learnt about the future potential of business opportunities that might emerge from disposal of oil as illustrated by Tshole Trust … The project could also instil entrepreneurial skills after they have finished college.'

Institutional capacity to embed ESD in the curriculum

The change project approach in these two institutions was based on two major premises. The first was to identify, plan for, create and reflect on a project – in order to change a situation of concern. Both colleges responded by generating a project, namely: a grey water recycling system in the FCE, and a system for the proper disposal of used oil at the MCE. Related to the first premise, the second was to enhance institutional capacity to initiate and support change in the field of ESD pedagogies, by linking this to the curriculum. Capacity-building workshops

seemed to deepen the understanding of ESD, and strong sustainability and agency. Capacity-building strengthened the understanding of ESD as practice-based, through the change project and its potential to reorient it towards the curriculum. For educators who were drivers of the projects, they used the change project as an organ that aided both fellow educators and students in bridging the gaps that exist in knowledge and skill. This was also reflected upon at the FCE in the research undertaken by some educators, who demonstrated this understanding by showing how the change project can be embedded in the various college subjects to mainstream ESD (see Table 1). For students at the MCE who drew on the change project to carry out their Science mini projects, this made their tasks manageable and achievable (Bell, 2010; Nation, 2008), an aspect emphasised by the educator who said:

> Since there is a topic of proper disposal of used oil in the Science syllabus, from this project other students were able to use it for their written project which is part of their assessment in Science which helped them because of their participation in the change project.

From these projects, students were able to drive their own learning through inquiry, to work collaboratively with others and make presentations. All this reflected the knowledge they acquired from the change projects (Sipos, Battisti & Grimm, 2008; Bell, 2010; Nation, 2008). Powers (2004), in her evaluation of school community place-based projects in the United States, found that there is a strong link between students' learning and their participation in community projects; she emphasised that 'closely related research has demonstrated that students who are engaged in real–world learning are more likely to succeed than are those who learn equivalent material from more abstract textbooks' (2004:18). She further reiterated that repeated case studies revealed that schools and communities throughout rural America have been transformed by grounding students' education through engagement in local community projects and 'intentionally moving away from didactic approaches to standardised schooling' (2004:18). The evaluation concludes that this approach, which is equivalent to the change project–based approach, increases their interest in their community issues (Powers, 2004; Sipos et al., 2008) – as was the case with the students who actively participated in the change projects.

ESD and strong agency across subject disciplines

In the initial phase of the change projects, especially at the FCE, it became apparent that monodisciplinarity and monosectorial practice still remain (Lotz-Sisitka, Wals, Kronlid & McGarry, 2015). This was particularly evident in the limited understanding of ESD as a cross-cutting concept in the Religious and Special Education departments, whose initial response in the capacity-building workshops was antagonistic and did not seem to comprehend the relevance of the change project in their subject areas. This was highlighted by the educator who said:

> The Special and Religious Education departments were initially reluctant to participate since they think this about the environment, they don't see where they fit … But when it came to building the tank students came from all subjects, including theirs!

This could be reflective of the observation made by Sipos *et al.* (2008), who argue that higher education in western societies overwhelmingly fragments knowledge into disciplines, and often leads to conflict between individuals and their ideologies. Lotz-Sisitka *et al.* (2015:74), in their argument for 'transformative, transgressive learning research and praxis in the sustainability sciences that appear generative of a higher education pedagogy', suggest that issues need to be understood and engaged via transdisciplinary perspectives, across multiple institutions, involving multiple actors. They contend that:

> In order to transform for the sustainability turn or transition, people everywhere will need to learn how to cross disciplinary boundaries, expand epistemological horizons, transgress stubborn research and education routines and hegemonic powers, and transcend mono-cultural practices in order to create new forms of human activity and new social systems that are more sustainable and socially just.

These authors are arguing for institutional departments to take a more reflexive approach, which breaks through their mono-discipline niches and transitions into negotiation, searching, and learning with others in order to bring about such transformations in their institutions (Lotz-Sisitka *et al.*, 2015:75). In the context of this study, this was partially achieved at the FCE, through attempts to create synergy among teacher-educators across the whole institution, by collectively planning, creating and reflecting on the change project development process (Han & Bhattacharya, 2001), through collective workshops and involvement of students from across the disciplines. The research that was conducted to reveal opportunities for change project mainstreaming could also assist in this regard. The aim was to get the two departments at the FCE, and other educators and students at the MCE, to buy into ESD through the production of a manual for those who initially did not see their role in these projects, or lacked understanding and enthusiasm towards the initiative.

Where some colleagues viewed change projects as located within a niche outside theirs, this synergy could open opportunities for reflection on such dominant pedagogies, and encourage pedagogies for sustainability that require transformation into new approaches to education processes (Sipos *et al.*, 2008). This is particularly important in teacher education institutions, whose products are a mass of teachers who are going to replay these same pedagogies in the schools across Botswana. Sipos *et al.* (2008) insist that if our collective goal is for a more sustainable future, we must manifest, encourage and impart values that contribute towards teaching for sustainability. This requires new approaches to education that will move teacher education towards the goal of interdisciplinarity by building bridges between academic fields. Through institutional change projects, the PBL approach proffers opportunities for this, as it provides roles for every stakeholder in the teacher education institution.

Collaboration and support through stakeholder participation
As has been observed in most projects undertaken where stakeholders' expectations about a project are high and the projects' sustainability is brought into question (Powers, 2004), we felt an ethical responsibility that effort spent by student-teachers and educators would not

be wasted if we provided the required support throughout the change project cycle from the planning to the evaluation stages. At the outset of the change projects, we collaborated with the Teacher Training Development of the Ministry of Education for support in capacity-building workshops, and the monitoring and evaluation of the change projects. As Lee *et al.* (2014) recommend, for teacher education institutions to experience success with PBL, and for PBL to become more integrated into their curricula, institutional support must be put into place; particularly from key stakeholders like the management of the institution, the Ministry of Education, and other key partners such as (in our case) the University of Botswana. This was clearly evident throughout the change project process, where there was sustained interaction among these key supporting agents and the institutions. At the FCE particularly, where the college principal was very enthusiastic, the barriers and obstacles encountered in the planning and creating stages of the change project were responded to collectively, which motivated the change project team facilitators and student-teachers to sustain their interest in the project.

Conclusion

The change projects seemed to increase motivation and engagement in learning for both educators and student-teachers. Student-teachers were the main beneficiaries, as they participated in and contributed to the change projects. The holistic approach introduced through change projects rooted in their participation connected them to the project activities and helped them view themselves as integral parts of the transformation brought about by these projects. It is therefore clear that PBL, through change projects, positively influences and motivates student-teachers to undertake tasks to solve environmental problems that affect them socially (Genc, 2015).

From these change projects it became clear that ESD for strong sustainability and agency requires educators to understand the interdependence and interconnections between disciplines (Yasin & Rahman, 2011). Hence, subject disciplines at these colleges need to come up with collective projects that will enable them to integrate the various issues and aspects in their various subjects (be they environmental, social, or economic) in order to develop interest in other disciplines (Nation, 2008). The process of learning can be enhanced through the incorporation of the diverse elements of change projects that call for more relevance to the real lives of the college community. Change projects can be used for both the content and its pedagogy, to achieve this objective of transformative and transgressive learning (Lotz-Sisitka *et al.*, 2015) in teacher education.

From this study, it becomes evident that PBL through change projects can offer the organising model (Sipos *et al.*, 2008) that unites pedagogic practices for sustainability within teacher education institutions. This approach provides a valuable bridge for interdisciplinary, practical and project-based sustainability pedagogies across the college subjects for transformative learning environments for student-teachers. However, future follow-ups on these change projects should still be considered, to raise questions about how and why some teacher-educators make the choices they do when implementing or resisting collaborative innovative pedagogies such as PBL, as was evident in the initial phase at the FCE.

While teacher–educators valued increased student participation, it cannot be concluded that they changed, except for those who showed their support of the change projects and participated. Another evident aspect was that, for the success of PBL in teacher education colleges, the value of institutional support from key stakeholders like the management of the institution, colleagues, the Ministry of Education and other key partners cannot be overemphasised.

Notes on the Contributors

Mphemelang Joseph Ketlhoilwe is an associate professor of environmental education at the University of Botswana's Faculty of Education. His research focuses on education policy, environmental education, and education for sustainable development, teacher education, evaluation, natural resources management.

Nthalivi Silo is a senior lecturer in environmental education at the University of Botswana's Faculty of Education. Her focus areas are environmental education curriculum issues and development of children's civic agency in environmental and sustainability issues.
Email: nthasilo@gmail.com

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Re-visioning Curriculum and Pedagogy in a University Science and Technology Education Setting
Case Studies Interrogating Socio–Scientific Issues

Overson Shumba, George Kasali, Yaki Namiluko, Beauty Choobe,
Gezile Mbewe, Moola Mutondo and Kenneth Maseka
The Copperbelt University, Kitwe, Zambia

Abstract

We present reflections on case studies in which a team of researchers and student researchers at the Copperbelt University in Zambia carried out real-world context investigations. The case studies involve estimating the greenhouse gas emissions associated with activities in the university, exploring agro-applications of biotechnologies, investigating chemical pollutants that are potential endocrine disruptors in the environment and in fish, and modelling how to mainstream the socio-scientific issues into curriculum and pedagogy for science educators and teachers. The analysis using the lenses of education for sustainable development (ESD) and 'learning as connection' lead to the suggestion of re-visioning curriculum and pedagogy. This re-visioning entails that the learning of the technical content of science subjects is balanced with a consideration of socio-scientific issues and ESD processes. Project-based learning provided the model for integrating the concepts and principles of ESD and 'learning as connection' into the curriculum and pedagogy.

Introduction

Over the past decade, the question of how education for sustainable development (ESD) contributes and/or re-defines quality and relevance of education has remained a critical concern for researchers and practitioners in southern Africa (Lotz-Sisitka, 2010; Lupele & Lotz-Sisitka, 2012). This concern for ESD and educational quality is important in higher education. For example, the Abuja Declaration on Sustainable Development in Africa seeks to transform the quality of learning and research beyond meeting academic and scientific objectives in higher education (Association of African Universities, 2009). The Association for Development of Education in Africa (ADEA, 2012) at its *Triennial on Education and Training in Africa* stressed the urgency of reorienting education to more effectively contribute towards creating sustainable societies. The Africa Union's Agenda 2063 is focussed on 'the Africa we want', envisioning a prosperous Africa based on inclusive growth and sustainable development where people have a high standard of living, quality of life, and well-being (Africa Union Commission, 2015). This vision will remain unachieved if the quality and relevance of African education systems is not re-visioned to mitigate the continued unsustainable exploitation of natural resources, construction, agriculture, and city and industrial development.

In the vision outlined in *The Africa We Want*, citizens of Africa are well educated and have skills underpinned by science, technology and innovations. The citizens, the ecosystems, and the entire African and global environments are healthy. Realising this vision will require

strengthening science, technology, engineering and mathematics (STEM) research, and research-based education in the next ten years (World Bank & Elsevier, 2014). It is therefore important for researchers to continue evaluating the contribution of ESD towards 're-visioning' curriculum and pedagogy in science and technology education settings, as well as the quality and relevance of educational practices for all.

Conceptual Framework

The realisation of the vision to reorientate and enhance the quality and relevance of African education systems, for purposes of spearheading the sustainable use of natural resources, requires an understanding of the concepts associated with these aspirations. In this regard, we used the lenses of ESD and 'learning as connection' to analyse and reflect on the quality and relevance of learning achieved in the case studies presented.

ESD seeks to promote the quality of education that provides knowledge, skills and values for sustainability, and reorienting the curricula and pedagogy (UNESCO, 2014). Competences in sustainability relate to acquired knowledge, skills and attitudes that help in successful problem-solving with respect to real-world problems, challenges, and opportunities (Ulisses *et al.*, 2015). Solving these complex problems will require that students understand what connections exist across disciplines, as well as how to make those connections when looking at societal problems and working with communities on matters such as climate change and environmental degradation. Such issues are not solvable by application of scientific knowledge alone. As such, the notion of 'learning as connection' has evolved as part of the debate centred on inclusion of knowledge forms and practices found in many local communities that are typically excluded when educational quality and relevance are seen through the lens of mastery and efficiency alone (Lupele & Lotz-Sisitka, 2012).

A 'learning as connection' discourse of educational quality views learning as actively interfacing context and concept and thus making connections to socio-cultural, socio-ecological, personal, and communal life-worlds and experiences possible (Lotz-Sisitka, 2008). Learning as connection advocates for education to be connected to contextual and historical dynamics of learners' life-worlds and experiences, while simultaneously gaining mastery of concepts and content. It thus provides for contextualised and locally referenced approaches to quality in science and technology education, as argued by Shumba (2012). In the case studies presented in this paper, student researchers conducted authentic and relevant research in which they studied and used the research data to leverage local action and strategies to tackle issues such as carbon emissions and climate change. This is desirable learning for the 21st century, as clearly pointed out in the Southern Africa Universities Association (SARUA) (2014) report 'Climate change counts'.

Purpose of Analytic Paper

This paper analyses and reflects on the experiences in which a research team and student researchers are engaged in research projects investigating real life issues. In doing so, the paper

seeks to suggest modalities for transforming curriculum and pedagogy in the area of science and technology education. The paper pursued the following questions:

- How can curriculum and pedagogy in a science and technology education setting be 're-visioned' for educational quality and relevance?
- How do ESD learning processes contribute towards a theory of 'learning as connection'?

Relevance to the Context

The Africa Union has a vision for Africa's sustainable development to be driven by science and technology. The vision aims to reorientate education with an ESD lens, as framed in the international discourse on educational quality. The following international processes on ESD suffice as examples endorsed by UN member states within Africa:

- The United Nations Decade of Education for Sustainable Development (UNDESD, 2005–2014);
- The Global Action Programme (GAP) for ESD from 2015 (UNESCO, 2014);
- The Incheon Declaration Education 2030 themed 'Towards inclusive and equitable quality education and lifelong learning for all' (World Education Forum, May 2015); and
- The United Nations Agenda 2030, themed 'Transforming our world' that contains the 17 Sustainable Development Goals (SDGs) (United Nations, September 2015).

SDG 4 target 7 in Agenda 2030 affirms the connection between ESD and educational quality, stating that all learners must 'acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles' (United Nations, 2015). Zambia endorses the above frameworks; hence, the latest *Zambia Curriculum Framework* seeks to integrate cross-cutting issues and ESD, and stresses the need to 'meet the individual and societal needs through learning' (Curriculum Development Centre, 2012:17). This reorientation of the curriculum requires innovations that must be shared widely. As it stands, there is not enough evidence available (even if anecdotally) as to how ESD contributes to the quality and relevance of science and technology education. This paper bridges this by providing and analysing case studies of student-teachers' ESD-oriented research projects within the science education department of a university.

Setting of the Case Study Projects

This paper analyses and reflects on researchers' experiences of and reflections on research projects they worked on with student researchers at the Copperbelt University in Zambia. The research team comprises a mix of natural scientists, science educators and an environmental management specialist. They considered the university to be an important site for ESD learning but did not fully understand its systematic integration into curriculum and pedagogy. As with academics elsewhere, they were preoccupied with their scientific disciplines. They tended not to preoccupy themselves with the curriculum and pedagogical issues considered relevant to the educational sciences. While in this setting mathematics and science student-teachers were

favourably disposed to mainstreaming of ESD into courses, ESD issues were not formally taken into account in designing their courses (Shumba & Kampamba, 2012/13). In other contexts, integration of ESD issues is resisted for the fear of dilution of or distracting students from the mastery of 'scientific' technical content.

In the university, there is considerable flexibility when it comes to research project courses where a student and supervisor can exercise their creativity in identifying research problems and research designs for their investigation and solution. The pedagogical landscape permits co-supervision; thus, teams of scientists, environmental managers/engineers, and science educators can work together for interdisciplinary support and reflections. The research projects have proven to be an important vehicle for introducing senior students to real-world research and thus important and effectual avenues for experiencing ESD learning, for both student and supervisor. This paper analyses and reflects on the case studies to evaluate (a) how curriculum and pedagogy in a science and technology education setting ought to be 're-visioned' for quality and relevance and (b) what ESD learning processes contribute towards the educational development of students and a theory of learning as connection.

The Case Study Projects

UNESCO stated that the vision of ESD is 'a world where everyone has the opportunity to benefit from quality education and learn the *values, behaviour and lifestyles* required for a sustainable future and for *positive societal transformation*' (2000:5, emphasis by authors). Emphasis has been added to underscore the fact that each case study research project was selected for its contributions to changing the learning landscape (to achieve transformation in personal, institutional and societal lifestyles). Nine research projects are analysed to understand the broader meaning and contribution they are likely making in research, curriculum and pedagogy in a science and technology education setting.

Tables 1 and 2 provide a synopsis of each of the nine projects selected. The basic import of the projects was to get the student researchers to appreciate the socio-scientific issues of carbon emissions, climate change and the contributions that young people (in this case university students) make towards carbon emissions in various ways.

The featured projects in Table 1 are those relating to students' consumptive behaviours and conservation practices regarding, for example, water (case study #1) and electricity (case study #2); transportation associated with student commuting (case study #3); and the use of air conditioners and refrigerators (case studies #4). The main consideration of the project was to ensure that student researchers investigated real-life socio-scientific issues, so that they acquired scientifically, socially and technologically informed findings regarding emissions and their association with global warming and climate change. Student researchers were expected to reflect on their personal behaviours and practices that contribute to carbon emissions. They were to locate and work with web-based resources (e.g., carbon calculators and software to quantify carbon emissions) and to propose viable strategies to mitigate them as part of their professional learning for environmental management.

The doctoral research (case study #5) investigated the risk to endocrine system disruption associated with organochlorine pesticides and phenolic compounds such as Bisphenol A and alkyl phenol ethoxylates in the environment and in fish, as well as the public's levels of awareness to the risks. Bisphenol A and alkyl phenol ethoxylates are widely used in industrial applications and consumer products such as plastics and laundry products. These substances are receiving worldwide attention as disruptors of the endocrine system in humans and wildlife. In addition to generating knowledge on endocrine system disruption, the research has educational value for bringing awareness to consumers and in environmental management.

Table 1. Case studies with scientific, technological and environmental focus

Title of case study	Focus of case study
Case study #1: Male students' behaviour and attitudes towards water consumption and conservation in relation to climate change.	Determined consumptive behaviours and volumes of water usage and wastage, leading to an estimate of the water carbon footprint.
Case study #2: Consumption of electricity in students' halls of residence and its contribution to the university's carbon emissions.	Investigated the types of electrical appliances used and their temporal patterns of use, and quantified the amount of electricity consumed and carbon emissions.
Case study #3: Estimating the carbon footprint associated with student-commuting at Copperbelt University.	Estimated the carbon emissions associated with student-commuting and recommended commuting management strategies.
Case study #4: Assessing the carbon footprint of refrigerants at the Copperbelt University.	Surveyed and quantified the carbon footprint associated with refrigeration and air-conditioning.
Case study #5: Potential risks of endocrine disruptors along the Kafue River.	Explored the risk to and the public and their awareness of the risk associated with endocrine system disruption by Bisphenol A and alkyl phenol ethoxylates in the environment and in fish.

Note: Case studies #1–4 are at the Bachelor of Science (Environmental Engineering) level and case study #5 is at Doctoral level (Biological Sciences).

While the projects in Table 1 are principally focused on knowledge production and problem-solving in the context of studying a socio-scientific issue, the projects in Table 2 were implemented by Masters' level science educators. They demonstrate the recontextualisation of knowledge for science and technology education in a teacher education setting. Their point of departure, like the projects in Table 2, is a focus on working with student researchers to explore real-life and problematic socio-scientific issues while tackling the concepts in the curriculum. Case studies #6–7 in Table 2 demonstrate the impacts on learning when engaging science and technology students in real life biotechnology research involving characterising and culturing cyanobacteria in bio-fertiliser trial experiments (case study #6) and characterising Fe- and S-reducing acidophilic bacteria in a mined area (case study #7). The teacher-as-researcher in case study #7 developed and tested the efficacy of delivering subject matter via multimedia presentations (*PowerPoint* slides coupled with video animation).

The remaining case studies in Table 2 demonstrate initiatives to integrate climate change education into a science teacher preparation curriculum (case study #8) and teaching a

science subject in a contextualised real–world context (case study #9). In the course of doing the projects, teachers-as-researchers came up with pedagogical strategies to assure that their students acquired relevant scientific and technological knowledge, knowledge of socio–scientific issues, and relevant environmental and ESD learning and skills.

Table 2. Case studies where scientific, technological and environmental is re-contextualised

Title of case study	Focus of case study
Case study # 6: Impact of engaging 4th year biology teacher education students in biotechnology research.	Explored the impact of engaging biology teacher education students in biotechnology research of cyanobacteria as biofertiliser.
Case study #7: Impact of using animations to teach DNA extraction to undergraduate students using an uncharacterised environmental sample from an actively mined area.	Evaluated impact of video animations in studying extraction and DNA characterisation of Fe- and S-reducing acidophilic bacteria.
Case study #8: Level of awareness of climate change concepts and the potential for greening the chemistry curriculum at Mufulira College of Education.	Engages lecturers and student-teachers in understanding and contributing towards designing the 'Green Chemistry Curriculum' at a college of education.
Case study #9: Impact of the Biological Science Curriculum Study 5Es Model on Zambian grade 11 learners' comprehension and attitudes on acid–base concepts in Chemistry 5070 studied in real world contexts.	Experimented with the Biological Science Curriculum Study 5E model and grade 11 students doing practical work with samples and materials in local environment.

Note: Case studies #6–9 are at the Master of Science (Science Education) level.

Analysis of the Projects

The nine projects were analysed by the research team using an analytic protocol developed for this purpose. An extract of the analytic criteria in the protocol are in Box 1. This protocol helped the researchers to qualitatively analyse and interpret educational and experiential knowledge accrued in the projects in a structured way, as recommended by Stake (2008).

Box 1. Criteria for evaluating scientific, educational, and societal impacts of the case studies

What value is added by the case study?
- Value added to our scientific and technological understanding.
- Value added to our understanding of the relationship between economic, environmental and social issues.
- Value added to decision-making capabilities of research team members.
- Value added to the quality of educational experiences.

What potential is there to transform some aspect of our curriculum practices?
- Potential to integrate of the subject matter content into research in the curriculum.
- Potential to connect learning of scientific and technological content to real life contexts, including social contexts.

- Potential to question people's actions and behaviours in light of the issues and findings.
- Potential to improve the relevance of the curriculum.

Are there any innovations or practical ideas coming out of the research project?
- Does it provide a viable solution to the problem?
- Does it have benefits to personal, community, and society?
- Does it provide unique ways of engaging students?
- Does it open scientific and technology knowledge to the wider community?

In the science and technology education and training of the university, what are the implications as you see them?
- A pedagogical approach to integrating development issues (e.g. environmental, social and economic issues).
- Connected learning in various disciplines.
- Promotion of multidisciplinary work and learning.
- Contextualisation of the curriculum.
- Integration of climate change and biodiversity.

The reflections of the team were focused on the 'big picture' pertaining to the overall meaning developed in the course of their execution. This big picture was assessed with ESD lenses and the learning as connection principle. An important question that was asked of each member of the research team was: 'What are the conceptual knots tying the project together?' This required each researcher to be reflective and to crystallise in their minds the wider meaning of the ESD research project in relation to the self, to science and technology, and in relation to appreciating the learning processes among student researchers as shown in the criteria in Box 1. In addition to the scientific and technological implications of research results, it was important to prospect for the educational and social implications of the research results.

Results and Discussion

The projects analysed are illustrative of ESD processes and learning. The projects engaged student researchers and supervisors in dealing with complex socio-scientific issues and development problems. Student researchers are learning to recognise ESD problems in the local institution and thus plan and implement investigations in which they collect data and use them as bases for action or proposing strategies to resolve the problem. A co-author of this paper reflected as follows on one of the projects:

> Electricity consumption in the university using students' residence halls is where the students embark on obtaining data and analyses it, provides real time data that fosters solving of problems within the community of practice while learning … The theory on carbon foot print calculations is brought closer to the students understanding by engaging in the research where analytical skills on climate change do not end with the figures but perceptions changing. (Choobe, co-author of this paper)

The case studies followed the pedagogical model of project-based learning (PBL) in which they confront and tackle real-life ESD issues (Segalàs, Ferrer-Balas & Mulder, 2010). As Segalàs, *et al*.

noted, this model provides an opportunity for student researchers to confront real-world issues and prepare them for solving challenges in society after university life. The PBL experiences had the following benefits:

- The projects improved student researchers' scientific and technological understanding of the issues and simultaneously raised their environmental awareness. One supervisor pointed out: 'As a supervisor, I was also able to observe how the student was able to intertwine the concept of carbon-offsets as a clean development mechanism and adapt it to his research.'
- The researchers viewed the projects as providing unique educational experiences for their students with respect to their ability to draw and use knowledge from several disciplines to solve a topical problem. For example, it was noted: 'In this study the student identifies a problem that affects the economy of the institution (electricity consumption) and links it to environmental problems of carbon emissions. The acquiring of the knowledge as being interconnected develops in the student.'
- Researchers reflected that engaging student researchers in projects of this nature had the potential to transform aspects of local curriculum practices in two ways:
  - Integrating research and the subject matter content of the research in the curriculum; and
  - Connecting scientific and technological content to real life contexts (including social contexts), thus improving the relevance of the curriculum.
- There were potential innovations and/or practical ideas that came out of the research projects; e.g., designing change projects, cost-saving measures, integrating socio-scientific issues in teaching and learning, and creating ICT and multimedia-based lessons.

In some of the case study projects, the student researchers tackled issues pertaining to climate change and its impacts. In others, they studied micro-organisms and tested their efficacy as bio-fertilisers. In science and technology education projects, they had to be innovative in order to effectively recontextualise scientific and technological knowledge into forms to be learned by non-professional scientists. To accomplish these tasks, student researchers were required to have acquired knowledge from several disciplines. In all projects analysed, student researchers required deep scientific and conceptual knowledge in chemistry, physics, biology, mathematics and engineering in order for them to provide efficient and sustainable solutions to contemporary global and local societal challenges. However, current university science, engineering curricula, and educational sciences do not provide such interdisciplinary courses and programmes.

It would appear that engaging them in projects that focus on socio-scientific issues ensures that the projects are interdisciplinary. This has benefits, as student researchers began to see their projects as enabling them to explore the interfaces between natural sciences and social sciences, and to make a link between scientific and humanistic dimensions of learning. The need to gain scientific knowledge of, for example, climate change science, should not be the be all and end all of learning in science education. Learning must include an understanding of the development issues associated with climate change and an appreciation of practical ways to act and do things to cope with or mitigate its impacts (see, for example, Eilks, 2015). The analysis

here shows that the projects provided opportunities to engage with scientific and technological subjects while also engaging with socio-scientific issues, and to propose or test change projects. Figure 1 suggests that pedagogical and curriculum innovations are needed to assure balanced treatment of subject matter contents, socio-scientific issues, and research or change projects/ activities to apply this knowledge to deal with developmental issues.

Figure 1. Balanced treatment of subject matter contents, socio-scientific issues, and research and change projects/activities
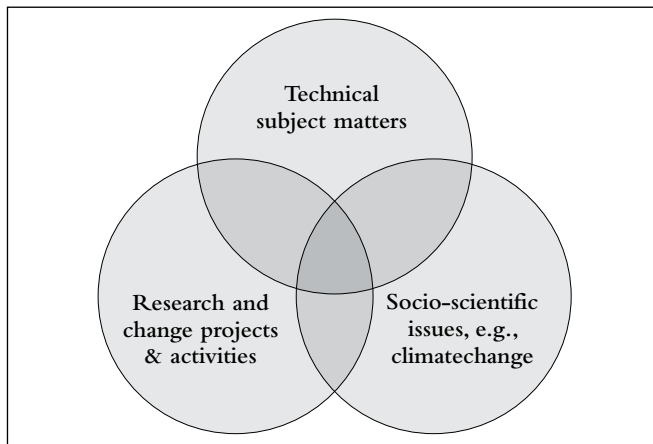
Source: Shumba *et al.*, 2012/2013

Implications: 'Re-visioning' Curriculum and Pedagogy and Learning as Connection

The experiences outlined above have shown that project-based learning focussed on socio-scientific issues can provide a context for problem-solving, knowledge generation and its recontextualisation, and for innovation in pedagogy in STEM education. The ESD processes that they entailed also have implications for 're-visioning' quality and relevance in STEM education. It has been shown that the creative nature of research projects makes it less rigid to investigate socio-scientific issues and create spaces for ESD learning. Properly conceived research projects guiding student researchers to draw knowledge from several disciplines can serve to break down the disciplinary cocoons in tertiary education, a major desirable shift for curriculum and pedagogy. Another important guiding point is in ensuring that they propose or design strategies to resolve the issues they find. For example, they ought to suggest carbon emissions management plans that involve them and other stakeholders, or pedagogical strategies to bring the process and results of real world science and technology investigations into classrooms. Furthermore, guidance ought to be provided on how to engage stakeholders with their sustainability action plans to mitigate a lack of knowledge or poor attitudes towards dealing with sustainable development issues. For example, in the various case studies, the survey components revealed poor knowledge concerning climate change and issues associated with it among university students.

The collaboration among the different specialists supervising the research projects also brings attention to what can happen to knowledge produced in the science departments if made available to science educators in teacher education. Here, it may be important to reflect on a point or two from sociologist Basil Bernstein. Bernstein's principle of recontextualisation is a pedagogic discourse, an ensemble of rules or procedures for the production and circulation of knowledge within pedagogic interactions (Singh, 1997) between science departments (that are fields of knowledge production) and science education departments (that are fields of reproduction, circulating the scientific knowledge). Recontextualisation, it would appear, is facilitated by collegiality and interdisciplinary collaborations among scientists, and science educators (and their students). In this case, knowledge and innovations in the research projects may be brought into the science curriculum for teachers and for schools. Pedagogical transformation is possible where socio-scientific issues are effectively integrated, balancing the science and technology content with consideration of the problematic development issues.

Besides the implications above, the experiences in these case studies are united by several 'knots' reflected in the concepts and practices that the researchers identified with: socio-scientific issues, cross-cutting issues, transfer of learning, interdisciplinary and multidisciplinary research, integration contextualising, community of practice, and several others. All of these concepts and practices point to connections and inter-connections that provide an important context for 're-visioning' of curriculum and pedagogy in the manner asserted above. This provides a case for learning as connection as a useful notion for understanding quality and relevance.

Conclusion

The challenge in ensuring educational quality and relevance, especially in Africa, is how to make the curriculum and educational experiences transformative for the individual and their society. Integrating and investigating real world socio-scientific issues in the curriculum and pedagogy can be achieved by utilising a project-based learning approach. As seen in the case studies, project-based learning with an ESD orientation provides the learners with real-life problems and a context for learning as connection.

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Notes on the Contributors

Professor Overson Shumba has research interests in ESD, chemical education and science teacher education. He is a former Fellow of the W.K. Kellogg Foundation and the German Academic Exchange Services, and member, UNESCO Monitoring and Evaluation Expert Group on the DESD 2005-2014. Email: oshumba@yahoo.co.uk

Dr George Kasali is an environmental microbiologist and senior lecturer with research interests in microbiology, climate change, bioenergy and environmental pollution.

Ms Beauty Choobe holds an MSc in Biology Education and has research interests in biology and ethnobiology education pedagogies.

Dr Moola Mutondo is a plant geneticist with a PhD from Max Planck Institute for Plant Breeding Research in Cologne. Her interest is research on organisms existing in extreme conditions.

Ms Gezile Mbewe-Chalwe is a molecular biologist and a doctoral candidate in biotechnology. Her research interests are in ecotoxicology, natural product chemistry, environmental biotechnology and food nutrition.

Professor Kakoma K. Maseka is a chemist with interests in chemical education, natural dyes and environmental chemistry with focus on polychlorinated aromatics and remediation of sites polluted with heavy metals.

Ms Yaki Namiluko is a lecturer in the Department of Environmental Engineering. She has research interests in natural resources management, climate change, remote sensing and geographical information systems.

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Teaching and Learning of 'Water for Agriculture' in Primary Schools in Lesotho, South Africa and Zimbabwe

By Tichaona Pesanayi and Farasten Mashozhera, Rhodes University, South Africa; and Lintle Khitsane, Lesotho College of Education, Lesotho

Abstract

Teaching youths about the subject of water for agriculture is vital in southern Africa where climate adaptation is imperative. Fresh water is a critical natural resource experiencing dangerous scarcity globally, with climate change and variability being key drivers. Agriculture consumes most of the allocated water in most of the southern African countries, so this sector needs particular water harvesting and conservation education. The Food and Agriculture Organisation (FAO) reported that 93% of cultivated land in southern Africa was rain-fed at the beginning of the 21st century. Drought hinders effective agricultural practices in poor-rainfall areas and is a common feature in most southern African countries. Increasingly frequent drought events affect Lesotho, South Africa and Zimbabwe chronically due to climate variability and change. These three countries have school curricula that carry agricultural and sustainability learning to varying extents. Agriculture is taught as a science subject, and tends to be inclined towards normative technicist approaches at the expense of traditional and innovative sustainability practices. This omission in curriculum development and teaching may miss the opportunity to learn from lessons offered by these traditional and innovative systems that have demonstrated resilience to climate variability and change. This paper explores the opportunities and enablers of sustainability learning and relevance in the primary school agriculture curricula of these three countries. The paper argues for inclusion of sustainable agricultural water learning as an act of educational quality and relevance that reflects 21st century socio-ecological, agro-climate and socio-economic challenges in southern Africa.

Key words: primary school, water for agriculture, rainwater harvesting and conservation, learning.

Introduction

Fresh water is a critical natural resource undergoing dangerous scarcity globally, mainly due to ecosystem degradation, population pressure, pollution, and climate change (FAO, 2011). The need for sustainable water resources is found in agriculture and other sectors that all compete for the resource (FAO, 2011). Sustainable agricultural water security refers to the management of water resources for agriculture, respecting the quality and quantity of the resource, minimising negative social impacts and promoting equity, ensuring access to and affordability by all (FAO, 2011). The new Sustainable Development Goals (SDGs) have a focus on improving water resources through poverty eradication (UNDP, 2014).

According to the Food and Agriculture Organisation (2002), 93% of cultivated land in southern Africa was rain-fed at the beginning of this century, and this may have increased with the depression of economies and climate change impacts (FAO, 2012). Agriculture is the mainstay of the economies of most Southern African Development Community (SADC) member states and the vehicle for food security (SADC, 2004). The important role of education and human capacity development in SADC integration is shown by the member states' commitment 'to eradicate poverty through increased public provision of ... education facilities and services' among others (2004:13).

Lesotho, South Africa and Zimbabwe share challenges that are brought about by climate variability and change, exacerbating poor economies and livelihoods. These challenges are characterised by over-reliance on rain-fed agriculture, compromising smallholder subsistence farming and food security (Thompson, Berrang-Ford & Ford, 2010). Enhanced dryness is a result of the regular El Nino phenomenon (SADC, 2015). These conditions impact heavily on agriculture, a sector that the majority of people engage in as smallholder subsistence or commercial large-scale farmers. The education systems of these countries have agriculture either as an independent subject or can be found integrated into different learning areas/subjects from primary level (except for South Africa) to tertiary education in diverse ways.

Our research interest in this paper was to find out how teaching, learning and texts in the primary schools in the three countries were including or excluding the theme of sustainable water for agriculture; in particular, rainwater harvesting and conservation (RWH&C). Water for agriculture (or agricultural water) refers to water that is committed for use in growing fresh produce and sustaining livestock, for which huge proportions of all the water withdrawn from rivers and dams are already allocated (FAO, 2011).

Methodology

A case study methodology was used in this study, using case studies that were conducted in three southern African countries – Lesotho, South Africa and Zimbabwe – on the teaching and learning of alternative water for agriculture in their primary school education systems. The counsel of multiple techniques use is sought from Yin (2008), who argues that validity is strengthened by the use of multiple instruments. A multi-case design was employed with the sample of primary schools in each country constituting the cases, and the unit of analysis in each case is the teaching and learning of RWH&C.

Study site and sample

The study was conducted in the Maseru district of Lesotho; Grahamstown's main township and its neighbouring rural area in South Africa; and in the Mutare urban and rural district of Zimbabwe. The study employed a small sample (number, n=21) in order to provide a snapshot of the extent to which RWH&C artefacts (objectives, topics, physical structures) for teaching and learning exist at primary schools, and to find out if their usage is supported by the curriculum. This could form a base for further, wider research on RWH&C and alternative water for farming for those who cannot afford or access irrigation. Public schools were purposively

sampled taking into consideration the presence or absence of RWH&C artefacts. Claims will be limited to schools characteristic of this sampling and may not be widely generalised. Qualified teachers with a teaching experience of more than two years, who taught across the different primary school phases, were selected in order to represent the whole primary school curriculum. In Lesotho these were foundation (grades 1 to 3), intermediate (grades 4 to 5), and senior grades (grades 6 to 7). In South Africa the phases covered were foundation (grades R to 3), the intermediate phase (grades 4 to 6), and senior phase of the primary section of the senior phase (grade 7). In Zimbabwe the selection covered teachers for junior primary, namely grades 1 to 3 and grades 4 to 7. In Zimbabwe, agriculture occurs as a subject in grades 5 to 7. The phasing is different in the three countries, but the age ranges and primary grades are comparable.

Data generation method

Questionnaires and interviews were used to generate data. A semi-structured questionnaire was administered to seven sampled teachers in each study site to generate primary data on the extent to which RWH&C is taught to learners, and the data was triangulated with one key informant interview in each site. The questionnaires were typed and contained a brief on the cover page about the purpose of the research and the rights and consent of participants who took part in the research. The questionnaire was organised into themes that covered subjects or learning areas where agriculture was mostly found, any topics that relate to harvesting and conservation of water, any practicals done by pupils, and water supply projects in the school. The questionnaires were administered between January and March 2016.

The questionnaire also covered issues of how teaching water in the school was related to pupils' water learning encounters in their communities. The interview schedule was organised in a similar way, but sought teachers' personal and professional relational experiences and efforts. Secondary data was obtained from the curriculum and syllabus documents as well as the prescribed agriculture textbooks from the three countries to find out how much RWH&C content had been included throughout the primary school years in order to support the primary data.

Data analysis

Data was analysed in three main sets: (i) curriculum documents, (ii) syllabi, and (iii) completed questionnaires and interviews. Questionnaires were manually coded, clustered and described according to emerging themes and ideas. The first level of document analysis was to generate data as described above, and the second level was to make sense of the data with respect to triangulation with interviews and questionnaires. The analysis focussed on any topics addressing water in agriculture with specific interest in RWH&C.

Results

This section shows the results of how teaching and learning of water for agriculture was reflected in the multi-sourced data. Availability and use of RWH&C structures in schools, and how they relate to education in water for food was considered a reflection of relevant artefact-mediated teaching and learning in climate and resource-constrained contexts.

Analysis of the primary school curriculum and prescribed textbooks

In the integrated curriculum for primary schools in Lesotho, RWH&C is implied under the scientific and technological learning area. In grade 1, unit 3, learning outcome 16, there is a concept of water conservation (GoL MoET, 2013a:79); while in grade 4, the concept is featured in unit 3, learning outcome 6, under environmental management (GoL MoET, 2013d:92). In grade 5 the concept 'ways of conserving water sources and their protection' is reflected in learning outcome 25 (GoL MoET, 2014:83).

The South African national CAPS for natural sciences and social sciences refer to agricultural indigenous knowledge (IK) in the senior phase (grade 7). The distinct water topic is 'ways of storing water in dams and water tanks', with no reference to agriculture (RSA DoE, 2010:29).

Agriculture is a stand-alone subject done by all learners in Zimbabwe in grades 4 to 7 and is guided by an agriculture syllabus. Soil and water conservation is a sub-topic under the topic 'water' in grades 4 to 7, while water harvesting is a sub-topic under the same topic in grade 5.

Step in Agriculture Grade 5 Pupil's Book is one of a number of Zimbabwe's prescribed textbooks for primary school agriculture that features water for agriculture (Sithole & Jeketera, 2013). Water for agriculture occurs as a sub-topic called 'water harvesting' under water, giving two examples or methods of water harvesting; namely rooftop to tank, and as diversion of part of a river.

In Lesotho, there are textbooks prescribed for each grade and they are organised according to units or learning areas. The Lesotho grade 1 learners' book describes how to save water under the topic 'I care about the world' (GoL MoET, 2013a:26), while in grade 5 the topic 'ways of conserving water sources' is captured in the scientific and technological learning area learner's book (GoL MoET, 2014:32). There are no prescribed textbooks to support primary school agriculture and water learning in South Africa as they appear neither explicitly as subjects nor as topics in the curriculum. Table 1 summarises the results of an analysis of inclusion of agriculture and water for agriculture in policy and pedagogic materials.

Table 1 provides for each country a summary of how agriculture and water are included or excluded in curriculum policy, syllabi and prescribed textbooks. There is a link between agriculture and water learning content from policy or syllabus to textbooks in Lesotho and Zimbabwe, while for South Africa there is a content gap. Teachers rarely use policy documents in Zimbabwe as they work more with syllabi, compared with Lesotho and South Africa where teachers work with curriculum policy statements regularly. However, the syllabi in Zimbabwe have some policy directions, clear aims and assessment objectives as indicated in Table 1. Lesotho's syllabus content is explicit on agricultural learning, for example, learning about manure and composting in school gardens for 'food production and agriculture' in grade 2 (GoL. MoET, 2013b:79). Zimbabwe has agriculture as a separate subject at primary school, South Africa does not have such a subject at this level, while in Lesotho it is under one of the learning areas. The prescribed textbook presents water for agriculture in various forms; for example, 'water harvesting' appears as a sub-topic of water and includes rainwater harvesting and water conservation. However, RWH&C for agriculture is explicitly included in both Lesotho and Zimbabwe syllabi and textbooks, as shown in Table 1.

Table 1. Summary of an analysis of the primary school curriculum documents in Lesotho, South Africa and Zimbabwe

Country and name of curriculum document	Inclusion of agriculture	Inclusion of water for agriculture
Lesotho		
Curriculum and Assessment Policy: (GoL MoET, 2009)	Agriculture under these learning areas: scientific and technological; creativity and entrepreneurial.	Implied under 'Environmental adaptation and sustainable development' (2009:22).
Syllabus	Gardens at school, home, villages. Learning resource grades 1,2 (GoL MoET, 2013a, b).	Water/moisture conservation, uses, source, are topics in grades 1 to 3 & 5 (GoL MoET, 2013a, b, c, e).
Text book(s): e.g. Learner's book by Letsabo, Lenyatsa (2016)	There are prescribed textbooks for each grade.	Conserving water resources: harvesting, storage in grade 5; mini-project to protect, conserve water sources (2016:33).
South Africa		
Curriculum policy: National CAPS Natural Sciences Senior Phase (Grades 7-9)	Agricultural learning is stated but only begins in the secondary grades. Indigenous knowledge includes agriculture and food production.	Management of soil and water (RSA DoE, 2011:8). Focus is on IK, not agriculture.
National curriculum and policy statement (CAPS) for Social Sciences	Agriculture referred to under intermediate phase History and in Geography, under settlement.	Ways of storing water; such as in dams and water tanks (RSA DoE, 2010:29).
Syllabus	The syllabus is incorporated into the CAPS.	The syllabus is incorporated in the CAPS.
Text book(s): none	No prescribed textbooks.	No prescribed textbooks.
Zimbabwe		
Curriculum policy: Agriculture recommended (Nziramasanga, 1999).	Syllabus objectives 2.6 'identify and solve agricultural problems' (GoZ MoEASC, 2012:2),	'Conserve natural resources… within their communities' (GoZ MoEASC, 2012:2).
Syllabus: Zimbabwe Grades 4-7 Agriculture (GoZ MoEASC, 2012)	Agriculture is a standalone subject.	Soil and water conservation a sub-topic in grades 4-7. Water harvesting is a sub-topic under 'water' in grade 5.
Text book(s): Grade 5 (Sithole & Jeketera, 2013)	Example of prescribed agriculture textbook for a grade.	'Water harvesting' for agriculture is a sub-topic (2013).

★Zimbabwe does not have curriculum and assessment policy statements that interface with teachers at the same level as in Lesotho and South Africa.

How primary school teachers perceive agriculture and RWH&C in the curriculum

Teachers in Lesotho indicated that agriculture was taught under the scientific and technological learning areas. They listed various topics related to RWH&C for agriculture including 'water conservation', 'conservation agriculture' and 'proper ways of conserving water sources'. Teachers in South Africa indicated learning areas that had a bearing on agriculture as 'environmental

sciences, social sciences, natural sciences, technology, life skills'. They also indicated that RWH&C was taught with a focus on domestic purposes and not agriculture. Apart from agriculture subject, teachers in Zimbabwe also identified social studies and environmental science as integrating agriculture and water learning. They listed the following topics where RWH&C featured 'water, soil and water conservation, crops, plants and animals'. The following areas were listed by respondents from all countries as spaces for practicals: vegetable production, school greening, soil and water conservation, and animal production.

Responses of teachers on RWH&C structures availability and usage in schools
Respondents from the three countries indicated that RWH&C structures available in the school campuses were boreholes, water tanks, dams, terraces and contours, as shown in Table 2.

Table 2. RWH&C structures availability and usage in schools (no. of respondents n=21)

RWH&C structures in school grounds	Number of occurrences of RWH&C structures in schools			Total no. of responses
	Lesotho	**South Africa**	**Zimbabwe**	
Water tanks	3	7	3	13
Boreholes	4	0	2	6
Dams	2	0	2	4
Others (contours, terraces)	1	0	1	2
None	0	0	1	1
Total responses	**10**	**7**	**9**	**26**

*Respondents were given more than one choice of structures to select from and/or add on

Water tanks were the most frequent RWH&C structure, with just under half the respondents in Lesotho and Zimbabwe, and all respondents in South African schools indicating the presence of water tanks in their schools. Boreholes, dams, contours and terraces also featured in Lesotho and Zimbabwean schools, but not South African schools in the sample. Contours and terraces featured the least.

Respondents across the three countries indicated that they also get water from municipal taps to perform agriculture practical lessons but noted cost as a limiting factor. Dominant agriculture projects done by schools in these three countries were vegetable production in school gardens, school greening, soil and water conservation, and animal production. Water tanks in the school campuses were stated to be for domestic use, irrigation of crops and gardens, and for watering livestock (for Lesotho and Zimbabwean schools mostly).

In Table 3 a summary of responses on the importance of RWH&C and the influence of RWH&C structures is presented.

Table 3. Responses of teachers to importance of RWH&C and value of structures

Probing questions	Responses per country	Country
Importance of RWH&C in schools	To teach water conservation, save on water bills, harvest water for school projects, and provide standby water sources during drought periods. For irrigation and domestic purposes (cleaning purposes), as well as for school vegetable and livestock projects.	Lesotho
	To cut walking distance to the water source, have constant water supply, cut on water bills, conserve rain water, and reduce collection of water in holes around school.	Zimbabwe
	To teach water conservation, save on water bills, serve as standby water, provide clean source of water (no chemicals in rain water), solve water shortages/crisis, cut distance walked to the taps.	South Africa
Availability of RWH&C structures and their influence in the teaching of agriculture	It instils a culture of water conservation, helps to store water for agriculture purposes. Enables schools to carry out curriculum based projects, collection and storage of water for later use. Provides materials for water-related practical lessons, as well as water for irrigation and for livestock. And help in the teaching of RWH&C.	Lesotho
	Provides free water to teach agriculture. Irrigation becomes easy. Avails water for promotion of practical lessons.	Zimbabwe
	Promotes water conservation through learning by doing. Provides awareness on saving water and an extra source of water for watering crops. Teaches self-reliance by conserving water. It makes economic and environmental sense.	South Africa

Teachers in the Lesotho sample indicated that RWH&C structures were important for 'irrigation of school vegetable and livestock projects'. Teachers from Zimbabwe indicated that availability of RWH&C structures will have an influence in the teaching of agriculture 'since it will be free water, teachers will be able to teach agriculture without wasting water'. Another Zimbabwean teacher said 'agricultural activities will increase as there will be more water to support these activities' (Teacher 4, 2016). The teacher considered harvested water as a free resource which enhanced agricultural teaching. On the importance of RWH&C, a teacher from Zimbabwe responded by observing that 'pupils understand more when they can actually see what we would be talking about' (Teacher 3, 2016) and another said there will be constant water supply for agricultural water learning.

Teachers in the Lesotho sample said that availability of RWH&C structures

[instil] a culture of water conservation, [help] to store water for agriculture purposes, to carry out curriculum-based projects, collection and storage of water for later use, avail water for irrigation and for livestock, provide materials for water-related practical lessons, help in the teaching of RWH. (February 2016)

The Lesotho and Zimbabwe primary school teachers demonstrated the relationship between RWH&C and agriculture teaching. The responses from South African teachers again show a link only with domestic use. Table 4 shows teachers' responses to questions on the relationship between schools and the surrounding community regarding RWH&C, with the aim of exploring use of structures for teaching and extension support to schools.

Table 4. Responses of teachers on the relationship between schools and community in relation to RWH&C

Questions	Responses	Country
Community RWH&C structures for teaching purpose	Used for field trips to learn about RWH&C structures and to teach water conservation topics.	Lesotho
	Helps to teach topics on sources of water, crop, plants and animals, as well as soil and water conservation.	Zimbabwe
	They are used to teach topics on climate and vegetation, water conservation, recycling, global warming, sources of water, water cycle, ways of storing water, water as a resource, and management/storage of water.	South Africa
Support from extension service	None/limited.	Lesotho
	They provide help in contour ridging, school greening, permaculture. Some schools did not get support at all.	Zimbabwe
	Provide water tanks, help in gardening, and are involved in eco-schools projects.	South Africa
Assistance required from extension service	Teachers require guidance on how to harvest rainwater, how to acquire RWH&C material, and request donations/ supply of water tanks. Awareness about water harvesting and proper use of water. Construction of safe dams. Guidance on vegetable production. Acquiring affordable means of harvesting water.	Lesotho
	Guidance in how to teach learners about vegetable production, diseases and pests. Provision of more information and knowledge in agriculture about constructing water tanks and protecting of water sources.	Zimbabwe
	Acquiring additional water tanks and replacement of roof gutters. Information on ways of treating tank water, building strong tanks, harvesting strategies and other methods of water conservation.	South Africa

Table 4 shows that RWH&C structures were used for teaching and learning of water sources, soil and water conservation, water storage, and climate. Water for agriculture was looked at differently by the responding teachers in the three countries. Only in Lesotho and Zimbabwe was there a link made between RWH&C structures and agriculture, almost by all respondents.

Six out of seven respondents from the South African case indicated that RWH&C structures were used for domestic purposes, and none linked them to agriculture. A teacher from South Africa described the type of extension the school received as 'there are people from public works who come weekly to our school and help with the garden and cleaning of grounds' (Teacher 1, 2016). This indicates that pupils' involvement in the school garden is minimal or non-existent. There is an indication that school agricultural activity in the South African sample area is linked to the Eco-Schools Programme, which works in only a few schools, under specified guidelines (WESSA, 2013).

The interpretation of the curriculum by teachers presented above is related to the content of the syllabi and learning support materials, as shown in the analysis of the primary school curricula of the three countries.

Discussion of Results

This discussion is based on the results of document analysis and responses from the 21 primary school teachers from Lesotho, Zimbabwe and South Africa involved in this study.

Summary of agricultural water and RWH&C inclusion and exclusion coverage in the primary school curriculum

The integration of rainwater harvesting for agriculture in the Lesotho and Zimbabwe sample teachers' responses is traceable back to the structural influences of policy and syllabi. External intervention by the Eco-Schools Programme in South Africa (done outside the official curriculum process) mediated learning of the subject of agricultural water, where participating schools voluntarily accepted it. This re-contextualisation process shows the power of the politics of knowledge (Rata, 2012), in what counts as knowledge to teach, and the effect of discretionary or official selection on pupils' learning opportunities. At another level, the re-contextualisation process from the syllabus to the textbooks shows the limiting of water harvesting methods to collection in tanks and diversion of parts of rivers (Sithole & Jeketera, 2013:32–33). In-field methods such as small farm dams and deep contours that innovative farmers have used very successfully (Denison & Wotshela, 2009) are not included. This partly explains the re-contextualisation done by the teachers that shows limitations on their knowledge of RWH&C techniques, as reflected in the responses from their interviews above.

Usage of availble RWH&C structures

Respondents in South Africa indicated that roof water harvesting tanks and municipal water were used as a source of water for school agriculture projects; while in Lesotho, boreholes and dams were popular. RWH&C structures that were in the community and available for use by the schools in those communities were water tanks, wells and dams for South Africa, Zimbabwe and Lesotho respectively. Of those structures identified, water tanks and dams were the predominant available RWH&C structures found in the sample schools and the communities in all three countries.

School and community relations

Community plays an important role in having and maintaining RWH&C structures, and availing them to schools for teaching and watering their gardens. In Lesotho, they were used for demonstration when teaching topics of water conservation and different structures used in RWH&C. In the Zimbabwe sample, they were used for topics in soil and water sources and conservation; while in South Africa, such structures were used to teach climate and vegetation, storage of water, and recycling.

Rainwater harvesting and conservation teaching and learning

In the Lesotho, South Africa and Zimbabwe primary schools, all respondents indicated that it is important to teach RWH&C as it helps in the teaching of water conservation, harvesting and storage for school projects. This was supported by the curriculum documents in Lesotho and Zimbabwe that included water and RWH&C learning for food production. The inclusion of RWH&C is relevant to the prevailing climatic, socio-ecological and economic contexts represented by the samples in these countries. Generally, policy and curricula were shown to be enablers of RWH&C teaching and learning in Lesotho and Zimbabwe. Most respondents indicated that RWH&C structures promoted learning, particularly by doing gardening, due to low costs, and they reduced water crises during drought events.

The South African primary school curriculum, however, has little significant agricultural water learning content. Evidence from an interview from an extension NGO indicates that primary school teachers in the sample area were generally reluctant to be involved in agricultural teaching and projects because the subject was not in the syllabus. This reinforces the idea that the South African curriculum policy constrains the teaching of RWH&C in schools for agricultural purposes by excluding it from primary schools.

Conclusion and Recommendations

The inclusion of agriculture and RWH&C in primary school curricula in Lesotho and Zimbabwe enhanced the learning of the subject of sustainable water for agriculture in the sampled schools. From the findings, this was not the case with the South African primary school curriculum and sampled schools. The exclusion of specific agricultural teaching and learning as a subject or topic in the South African primary school curriculum may have implications for pupils' valuing of agriculture and alternative sustainable water for agriculture. Studies on how this exclusion may affect the preparation of the youth for future self-reliance opportunities in agricultural production are recommended. We also recommend that topics of water harvesting and conservation, and food gardens be included in the South African primary school curriculum, as these are heavily promoted by research and national policies. The type of RWH&C promoted in the primary school curricula of all three countries in this study were mainly limited to roof-water. This limits the learning of possible sustainable water for agriculture methods available, such as small farm dams, deep contours, fertility trenches and mulching. The inclusion of sustainable water for agriculture learning, particularly RWH&C, is relevant for adaptation to the socio-ecological and agro-climatic challenges prevailing in southern Africa. Further research

on the learning of alternative sustainable water for agriculture across teacher education, school and community contexts is recommended. Finally it is recommended that curriculum reviews and changes consider integrating or strengthening learning of sustainable alternative water for agriculture and featuring knowledge practices of farmer innovators.

Notes on the Contributors

Tichaona Pesanayi is a Rhodes University/Southern Africa Education for Sustainable Development research fellow. Tichaona's current research interests focuses on co-engaged social learning across boundaries within water, seed security and natural resource management activity. Email: tichpesanayi@yahoo.com

Lintle Khitŝane is a lecturer in agricultural education at Lesotho College of Education. She holds a Master's degree in agriculture. Her research interest include natural resources conservation and change-oriented education.

Mashozhera Farasten holds an MEd (Science Education) from Rhodes University and is an educator at Grahamstown Adventist Primary School, South Africa. His research interest is in primary school teachers' and learners' experiences of food gardens.

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Viewpoint

A Viewpoint of Personal Aesthetic Preferences and Aesthetic Education, Landscape Theory and Survival in the Kalahari Region of South Africa: Implications for an Authentic Contemporary Curriculum

Jannie Pretorius and Okkie Combrinck, University of the Free State;
and Stephan du Toit, Australian Catholic University, Sydney, Australia

Abstract

In this study the authors explore the evolutionary origins of their personal innate landscape preferences and connect these to some of the prominent elements of current landscape theory. By considering their personal preferences for aesthetically pleasing elements of the landscapes of the Kalahari region of South Africa, the authors present a personal interpretation of what aesthetic education might have required from their ancestors in prehistoric times and what this might imply for educationalists in the 21st Century.

Keywords: Landscape theory, aesthetic preferences, aesthetic education, survival, Kalahari region of South Africa

Introduction and Aim of Study

This paper explores the evolutionary origins and development of humankind's aesthetic preferences and education. The main hypothesis guiding this paper is that humankind's aesthetic preferences had their evolutionary origins in the Pleistocene (between 2.5 million and 11 700 years ago). These preferences would have developed because of our ancestors' ability to decide whether specific habitats or landscapes would sustain them or not; therefore enabling them to reproduce and raise their children. The argument presented to support this hypothesis is simple and strongly convincing: The habitat that sustained our prehistoric ancestors became aesthetically pleasing to them. If they made the right habitat choice, they survived. If they made the wrong choice, they died and would therefore have been unable to produce offspring.

The hypothesis introduced above is called the 'The Savanna Hypothesis' and it was developed by researchers including Jay Appleton, Roger S. Ulrich, Stephen and Rachel Kaplan, Gordon H. Orians and Judith H. Heerwagen (Ruso, Renninger & Atzwanger, 2003:280–1, 284; Dutton, 2009:19). Dutton formulates the hypothesis as follows:

> Orians put forward a general account of the kind of ideal landscape that human beings would find intrinsically pleasurable. In his formulation, this landscape has much in common with the savannas and woodlands of East Africa where hominids split off from chimpanzee lineages and much of early human evolution occurred; … The ability to recognise this preferred habitat was embedded in the human gene pool and was (and is) presented in humankind's universal artwork of choice: the landscape painting. [See Figure 1.]

Figure 1. Dutton (2009: Illustration 2): 'Grand landscapes, such as Frederick Church's *Heart of the Andes* (1859), tend to use patterns of varied open spaces and forested areas, water, and a path that appears to lead intriguingly into the distance. The worldwide attraction of such landscapes even today is very likely an evolved trait.'

Briefly, this landscape type includes these elements:
- Open spaces of low (or mown) grasses interspersed with thickets of bushes and groupings of trees;
- The presence of water directly in view, or evidence of water nearby or in the distance;
- An opening, in at least one direction, to an unimpeded vantage on the horizon;
- Evidence of animal and bird life; and
- A diversity of greenery, including flowering and fruiting plants (Dutton, 2009:19, 20).

Orians and Heerwagen (1992:556–557) suggest that, to understand the importance of habitat selection to our hunting and gathering ancestors, one should go on an imaginative camping trip that lasts a lifetime:

> You wake up one morning with an empty stomach and an empty cupboard. It is time to move on. Clouds on the horizon indicate that it has rained for many days in that area, and this is where you will head to look for food … The small band of adults and children gradually begins the long hike across new terrain … They discuss the route they should take, recalling where they found the best berries, fruits, and leafy greens last year.

Taking the above into consideration, we have formulated the twofold aim of the paper:

- To personally contemplate what habitat selection and survival in prehistoric times was all about; to appreciate the five elements that might have determined the habitat selection and survival of this imagined small, rather vulnerable group of prehistoric people; and
- To comprehend how they might have educated their children to survive in a rather hostile environment.

To achieve this aim we needed to consider what habitat selection and survival in prehistoric times was all about by connecting our personal aesthetic preferences to the five elements of an ideal landscape. One would have to spend some time in a comparable environment to accomplish this aim. But where would one find a suitable savannah region?

The Kalahari in southern Africa is just such a region, and includes the following sections: the eastern parts of Namibia, the north-western parts of the Republic of South Africa, the biggest part of Botswana, parts of Angola and a large part of western Zimbabwe (Erasmus, 2004:142). We needed experiences in the savanna of Africa to establish personal connections with modern landscape theory. But where in the vast Kalahari would we find a suitable landscape for our endeavours?

Setting the Scene

Koos Becker is a farmer and longstanding friend of the first author and agreed (Becker, 2010, 2012) to act as our host for the two visits. He owns three large Kalahari farms approximately 120km to the northeast of Upington in the Northern Cape Province of South Africa (see Figure 2). Koos lives here with his wife Vinie and their two adult sons Stephan and Burger. A visit to the Kalahari by the first author in July 2010 was followed by a more extensive one by all three authors in July 2012.

Koos also promised to share his knowledge of the animals and plants of the veld. This was a huge bonus, since he was born and raised in the Kalahari. Koos said that we could hunt for some springbuck to make biltong (salted, dried elongated pieces of meat enjoyed by many South Africans).

This final piece of our Kalahari puzzle fell into place, adding a very special dimension to our visit. We could hunt for food much like our prehistoric ancestors did; even if it was with a rifle and not primitive weapons. Here we could experience some of the realities of our prehistoric ancestors.

Figure 2. Exactly what we needed: 'open spaces of low (or mown) grasses interspersed with thickets of bushes and groupings of trees' (Dutton, 2009:19).

An Interpretation of Landscape Theory, Survival, Aesthetics and Aesthetic Education

We have structured our personal interpretation of landscape theory, survival, aesthetics and aesthetic education in the Kalahari per the five elements of an ideal landscape that appear in the introductory paragraphs. We will now consider our personal aesthetic preferences – what we consider to be beautiful in the Kalahari landscape – and embed them in the five identified landscape elements. In the process, we will highlight the possible implications of these considerations for aesthetic education in ancient and modern times, as well as for ancient and contemporary curricula.

Elements of an Aesthetic Landscape in the Kalahari and the Possibility of Prehistoric Aesthetic Education

The shape of savannas
According to Dutton (2009:20), high-quality savannas are characterised by *Acacia tortilis* or umbrella thorn, a spreading tree that branches close to the ground: 'A climbable tree was a device to escape predators in the Pleistocene, and this life-and-death fact is revealed today in our aesthetic sense for trees (and in children's spontaneous love for climbing them).'

In the Kalahari our preferred tree for jumping into when running away from a dangerous animal would be the camel thorn, or *Acacia erioloba* (see Figure 3). The branches of this tree are close enough to the ground for us to reach (see Figure 4).

Figure 3. A group of camel thorn trees, Acacia erioloba[1]

Figure 4. Branches close enough for us to reach
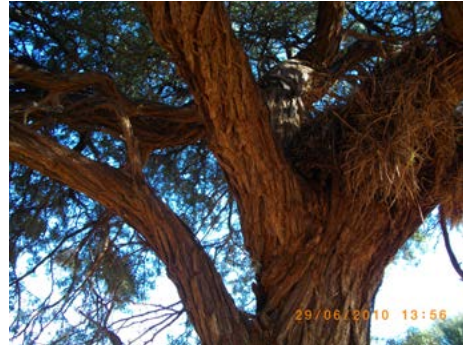
The admiration and personal affection that we feel for the camel thorn is difficult to explain without getting too sentimental about it. Are they part of our innate landscape preferences?

Evidence of animal and bird life

During one of our visits to the veld, Koos pointed to springbuck tracks leading to a small camel thorn (see Figure 5).

Figure 5. Springbuck tracks leading to the pods of the camel thorn

Figure 6. A springbuck feeding on nourishing camel tree pods

He explained that, because the wind had been blowing strongly overnight, many pods had dropped on the sand. The tree, in order to have its seeds distributed, packs its pods with nourishing proteins − 11.4% rough protein in the pods and 33% in the seeds − and lures the antelopes into eating them, disseminating the seeds elsewhere, so they might germinate and develop into a new tree (Venter & Venter, 2009:18).

Shortly after Koos's explanation, we indeed saw a springbuck feeding on the pods under a camel thorn tree (see Figure 6). To us, this was very interesting, since this might be exactly the kind of information one would share with your children if you wanted to educate them to survive in the Kalahari. This would have been a key element of the prehistoric Kalahari

curriculum. The prehistoric man, looking for a suitable place to set his snare or wait for an antelope to shoot with his bow and arrows, would improve the survival rate of his tribe if he knew this.

By pointing out the tracks in the beautiful red sand of the Kalahari, Koos has made us aware of the multitude of other tracks and signs of life, like the dry droppings of antelope (see Figure 7) in the sand.

We gradually developed this impression: the sand of the Kalahari is like a huge canvas, with animals, humans and plants all 'painting' on it (see Figures 8 and 9).

Figure 7. Dry droppings of an antelope; clear indications of animal life

Figure 8. Nature's canvas, evidence of animal, insect and bird life
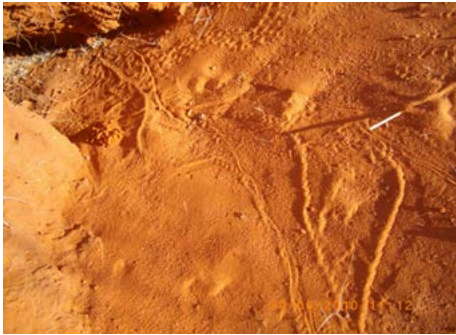
Figure 9. A tapping beetle creating a small work of art in the sand

Because of the wind, these small artworks are only temporary, but they have fascinated us as they must have fascinated our prehistoric ancestors. Because each set of tracks could lead to a potential food source, we believe they would have captured the attention of our ancestors, triggering their imaginations. The Pleistocene people, by following these tracks and the other signs of life, by interpreting them, by educating their children about them, have survived for millennia in the Kalahari.

Hidden water

One might argue that, because of the almost complete absence of permanent surface water in the Kalahari, the region might not be unable to sustain human populations. This would be an erroneous argument since the Kalahari has supported human populations for thousands of years. The indigenous San people, for example, have followed the herds of antelopes during their seasonal movements and they have collected tsammas melons (*Citrillus lanatus*) to provide them with water (see Figure 10). The tsamma (San word meaning 'speckled water') contains a juicy meat with a water content of up to 90% (Steyn, 1984:58) and can remain unspoiled on or in the sand for months, ready to supply people and animals with water during the dry winter. The San stored these valuable fruits in holes dug by animals in the sand, and in the trees on their routes to provide them with water on their return.

Figure 10. Life sustaining water reservoirs in the Kalahari – tsamma melons

San people would have made mental maps of the positions of the tsammas over great distances, and interpreted animal tracks, the weather and all the other components of their landscapes. They also would have needed to educate their children about these things, which might be the origin of the educational experience. For the Pleistocene people, just one misinterpretation of a set of tracks, or one mistake in the interpretation of predator behaviour, might have been enough to threaten their chances of survival. Education in prehistoric times was a matter of life and death. Anyone who did not grasp the importance of education in the realities of the Kalahari did not survive, and did not reproduce. The content of the Kalahari curriculum has received meticulous and ongoing attention. It was never written down, but such was the importance of every detail, that the omission of even the slightest scrap of information might have been fatal. These arguments are probably supported by what Schadenberg (2002:11) said in 1959 about the indigenous San of the Kalahari: 'The San are a highly intelligent, skilled and organised people who move with purpose or remain with reason.'

The unimpeded vantage

During the first author's visit in 2010, the rather basic accommodation, a cabin (see Figure 11), had two small rooms with the front facing in a southwestern direction, which was excellent, since a rather cold, strong wind was blowing from the north on that day. Not only did the cabin provide him with protection against the volatile elements of nature, but also with an unimpeded 180° view of the horizon.

Figure 11. A cabin with an unimpeded vantage on the horizon

During the second visit, we stayed in an empty farm house built in the open space between two dunes – called a street – which left us with a partially impeded view of the horizon (see Figure 12).

We contemplated the effect this had on our intuitive assessment of our accommodation and surrounding landscape and concluded that we would have preferred to stay in the cabin. Our preference was quickly supported by a surprising observation: when elevated by some of the higher dunes while walking in the veld, we were surprised by the tremendous distances over which early morning sounds and our voices were audible. We concluded that our preference for elevation was based on its ability to enable us to hear possible predators or prey – and maybe also our prehistoric tribe's communication – over great distances.

Figure 12. Our accommodation in the 'street' between two dunes

Figure 13. Stoffel (on the right), an expert at slaughtering springbuck, and Stephan, Koos's son

Further support for this was also provided by our hunting experiences: when standing on the dunes, we could detect the antelope over vast distances. Standing with your rifle on the back of a 4X4 utility vehicle elevates one even higher, and was the best way to hunt for springbuck in the Kalahari: we shot three springbuck (see Figure 13).

A diversity of greenery

We find the different plant species of the Kalahari aesthetically pleasing. Many are useful sources of medicine and food. Their presence, and knowledge about them, might contribute even to this day towards our survival. One example is considered sufficient to illustrate the importance of this element for habitat selection and survival.

The roots of the beautiful shepherd tree (*Boscia albitrunka* – see Figure 14) might be dried and used as a replacement for coffee or 'porridge' (Venter & Venter, 2009:72). Animals, and possibly prehistoric humans, could eat the bark to combat internal parasites (see Figure 15). The temperature in the shade of this tree might be as much as 21°C lower than in the open sun (Steyn, 1984:58), therefore the tree offers much needed protection for humans and animals against the extremely hot summer sun and potential dehydration in the Kalahari.

Figure 14. A shepherd tree

Figure 15. The shepherd tree's bark damaged by animals

Conclusion

The first part of our twofold aim was to contemplate our personal aesthetic preferences and connect them to the five elements of an ideal savannah landscape. The personal aesthetic preferences that we have unearthed during our visits to the Kalahari have indeed resonated very strongly with the five elements included in landscape theory.

The second part of our aim was to develop a comprehension of how prehistoric people might have educated their children to survive. We have recognised the importance of a detailed, meticulous education about the elements of the landscape to ensure the survival and successful reproduction of the bands of hunter-gatherers that roamed prehistoric savannah landscapes.

Reflection and Implications

We attempted to uncover any hidden remnants of the lifelong camping trip in the lives of modern families in the 21st Century: are they still studying and assessing the elements of the concrete landscapes they are struggling to survive in, and are they still taking decisions based on their observations? Dutton (2009:4) puts the questions in more specific terms: 'How do the pleasures of playing video games or listening to fugues derive from instinctive processes that were in place tens of thousands of years ago?' What about movies that are so freely available on television and the internet?

Dutton (2009:133) argues that it is easy to overestimate the importance of film and video since 'visual extravaganzas did not begin with Hollywood but very likely amazed audiences in Palaeolithic caves, with firelight and cave echoes providing their special effects.' Dutton's underlying assumption is clear, though: that film and video – and for that matter many forms of modern technology – are extensions of the play in the cave or the beautiful landscape. The television and computer screen have therefore reported themselves pertinently to us as modern equivalents of the unimpeded view on the landscape, and we are quite happy to pursue the idea further here. The universal popularity of this electronic equipment, and the sheer scale of new developments being introduced into the modern marketplace, might seem to us like indications of families' evolutionary needs being satisfied on an unprecedented level. The small group of contemporary hunters-gatherers – the family – watches television and surfs the internet to experience what their prehistoric ancestors did by walking: a camping trip that lasts a lifetime.

If one accepts an evolutionary explanation as the basis for the popularity and importance of these devices, the next step is to contemplate how they are utilised by the contemporary family during the process of habitat selection in the modern era. A comprehension of how fleeting landscapes appear at an astonishing speed on the different television channels and websites in our homes, now enables us to connect the lifelong camping trip of Pleistocene landscapes with a virtual one in the technological landscapes.

Families are still making life-and-death decisions about landscapes, and are still on camping trips that will last for their entire lifetimes; but now they are virtual trips, made in the luxurious environment of their sitting rooms. Cosgrove (2008:31) argues that the place of technology within modernity is central, practically, mythically and rhetorically, and that 'only a superficial

reading of cultural history would suggest that the mechanistic and inorganic aspects of technology have actually resulted in a lessened appeal of landscape.'

The troubling question is: are we reflecting these realities in the kind of education we present to our teenagers today?

Note

All photographs taken by Jannie Pretorius.

Notes on the Contributors

Jannie Pretorius is a senior lecturer in the School for Mathematics, Natural Sciences and Technology Education at the University of the Free State. His research interests include aesthetic education, appreciative inquiry and popular music. Email: pretoriusjph@ufs.ac.za

Okkie Combrinck is an associate professor in the School for Mathematics, Natural Sciences and Technology Education at the University of the Free State. His research interests include engineering graphics education, aesthetic education and appreciative inquiry.

Stephan du Toit is a lecturer in mathematics education on the Strathfield Campus of the Australian Catholic University. His research interests include metacognition and problem-solving in authentic situations.

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Viewpoint
Environmental Slogans:
Memes with diverging interpretations

Christo Fabricius and Samantha McCulloch,
Sustainability Research Unit, Nelson Mandela University, South Africa

Abstract

Environmental slogans can be seen as memes, i.e. cultural constructs that, not unlike genes, replicate themselves from one generation to the next. Memes may, however, be divergently interpreted and some memes can even have unwanted side-effects. We wanted to find out how supporters of an environmental non-governmental organisation (NGO) interpreted their slogan 'People Caring for the Earth'. During a celebratory event of one of the NGO's branches we asked 65 supporters of the organisation to write down their interpretation of the meaning of the slogan, as well as the actions that they regularly engage in to give substance to it. Fifty-eight per cent of the 34 respondents gave social-ecological systems interpretations of 'Caring for the Earth' and interpreted it as humans living sustainably with nature. Their associated actions centred around sustainable living principles. Forty-two per cent of respondents held strong nature-centric interpretations of the slogan, understanding it as a call to conserve species and ecosystems. Their associated actions centred around awareness raising and educating others. While these were broad patterns rather than exclusive, distinct categories, our results suggest that environmental memes should be used with circumspection, that their meaning should be clarified through actions rather than words, and that organisations should give as much attention to the meaning of their slogan as they do to the environmental causes they aim to address. The way environmental slogans are perpetuated within an organisation has implications for the membership they attract or deter.

Introduction

Memes are ideas, habits or fads that replicate themselves from one individual, generation or group to the next through imitation. In that sense memes are the cultural parallels of genes in biology (Dawkins, 1976). Dawkins argued that successful memes get replicated because, like replicated genes, people who use them survive longer with a positive feedback loop between the habit and the meme. In a later essay, Dawkins (1993) likened memes to mind–viruses and explained how difficult it is for society to get rid of them when they become maladaptive or obsolete.

Some memes can be very stubborn or sticky, for example, modern advertising slogans such as 'Just do it', 'Have a break …', 'A diamond is forever' or 'It gives you wings'. Many memes are harmless or even good, but some can have unwanted side effects (Atran, 2001). The swastika,

nowadays a symbol or meme for Nazism, was (and still is) also an emblem of well-being and good fortune in many cultures. Dating back 15 000 years, it had only positive meaning, before the Nazis assigned their own interpretation and propaganda to it. Another example of a meme gone rogue is 'Unity is Strength'; a seemingly admirable slogan until it became misused by the former South African government to unify white South Africans against the 'total onslaught', a purported communist conspiracy against the country's sovereignty. It will take many generations to overcome the resulting disunity. Memes are powerful communication and marketing tools and should be promoted and used with circumspection.

Environmental slogans such as 'Caring for the Earth' (IUCN & UNEP, 1991), also called 'Earth stewardship' (Chapin *et al.*, 2011) can be powerful memes. A call to voluntary, unselfish actions, where everyone shows leadership and takes responsibility to promote the long-term sustainability of Earth (Barendse *et al.*, 2016), 'Caring for the Earth' is used worldwide and in South Africa. It is variously used as a guiding principle for sustainable living (IUCN & UNEP, 1991), a yardstick for better policies for a more sustainable world (Robinson, 1993), a spiritual or meditation practice (Berry, 2006), a call for morality and citizenship (Rolston III, 2012), and a pathway to community resilience (King, 2008). It seems 'Caring for the Earth' has gained traction. But does it have universal meaning?

Methods

The slogan of the Wildlife and Environment Society of South Africa (WESSA) is 'People Caring for the Earth'. In July 2016, the Garden Route branch of this non-governmental organisation marked its 90th anniversary with a celebratory dinner, under the banner 'Celebrating 90 years of Caring for the Earth'. This presented an opportunity to test members' understanding of a slogan that all of them presumably subscribed to.

Sixty-five members and supporters attended the event where funds were raised by charging an entry fee. Attendees were white and mostly English-speaking South Africans in the 40–80 age group, except for two high school scholars and three university students who were in the 18–30 age group. After a brief introduction and verbally obtaining their permission, we asked all participants to write their personal interpretations of the slogan 'Caring for the Earth' on individual 80 x 120mm cards. In addition, they were asked to list activities they regularly engaged in – activities that gave substance to their interpretation of caring for the earth – on the reverse side of each card. Results were analysed using qualitative content analysis software (Atlas-ti) by labelling synonyms with the same code. Analysed results were visually displayed using word clouds that related the size of a word to the number of times it occurred in the sample (Shackleton *et al.*, 2016).

Results

Thirty-four participants completed cards, from which we discerned two broad categories of interpretations. Fifty-eight per cent of participants held social-ecological systems interpretations of the slogan. They saw it as a collective mission where people looked beyond their own

interest, and where humans and nature are part of the same system. Statements such as 'keep Earth alive for all of us', 'sustainability of environment and development' and 'fit in with the environment' were indicative of this understanding. This interpretation went hand-in-hand with an understanding that caring for the earth was about living responsibly and treading lightly on the planet. 'Living with a light footprint' and 'limit our impact' were typical comments, with recycle, save water/electricity, limit population growth as representative actions (Figure 1).

Figure 1. An all-embracing, social–ecological systems interpretation of Caring for the Earth emphasises sustainability, treading lightly on the planet and limiting our ecological impact. The relative size of a word indicates the number of times it occurred on cards in this category.

On the other side of the spectrum (42% of responses) were participants who understood the slogan as a call to conserve and preserve nature. This grouping included interpretations such as: preserving all species, conserving endangered species, eradicating alien plants, stopping littering and preserving nature for the next generation. Activities included protest action, campaigns to save endangered species, preserving wildlife, planting trees and bringing problems to the attention of the authorities. This group generally saw the solution as education and awareness raising, with comments such as 'promote awareness amongst the youth', 'spreading the message', 'educating/teaching others' as examples of activities (Figure 2).

Figure 2. A preservationist interpretation of Caring for the Earth emphasises conservation of species and natural ecosystems for future generations and focuses on awareness raising and education as solutions. The relative size of a word indicates the number of times it occurred on cards in this category.

Discussion

This exercise, despite the small sample size, supports the view held by Atran (2001) and others that commonly used slogans (or memes) such as 'Caring for the Earth' can be susceptible to inconsistent interpretations. It seems most people caring for the earth in the Garden Route have a broad, inclusive understanding of this slogan. They see it as a lifestyle choice that they act out by reducing waste and using resources sparingly. They typically see the responsibility for achieving this as everyone's, with themselves as part of both the problem and the solution.

Other respondents, subscribing to the same slogan, held a more nature-centric view with a focus on species preservation, eradicating problems and protecting the Earth against human threats. People in this category tended to believe in education, fund-raising campaigns, protest and raising awareness among others as the solution to environmental issues. The two groups are not necessarily clear-cut and as distinct as portrayed here; a person can have a broad understanding of sustainability, be concerned about extinctions *and* be passionate about education and awareness raising.

What our quick survey did show is that even supporters of the same environmental cause might differ in their understanding of an internationally and locally used slogan, and that this may be associated with different actions as expression of such understandings. People appear to assign their own meaning to memes, and to act accordingly. This may explain why members of organisations may differ among themselves about where to focus their attention, in which case the slogan is not a universal rallying call. The ways in which environmental slogans are understood and given meaning through action, also have implications for an organisation's image, especially amongst its potential future membership base. The activities and actions of environmentalists could very well be more powerful than their slogan in influencing the stickiness (or otherwise) of a meme. 'Caring for the Slogan' is perhaps another cause to which environmentalists should attend.

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Notes on the Contributors

Prof. Christo Fabricius is head of the Sustainability Research Unit at the Nelson Mandela University's Madiba Drive Campus in George. He specialises in ecosystem management plans and strategies, ecosystem restoration plans, and sustainability and resilience assessments, promoting responsible management of the Earth's resources. Email: christo.fabricius@nmmu.ac.za

Samantha McCulloch is a member of the Sustainability Research Unit at NMU. She has recently begun her PhD, focusing on network governance and learning to promote management efficiency within the GEF 5 programme.

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