CHAPTER 13

Emergent Curriculum and Sustainability Competencies in Environmental Learning

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Introduction

This study was influenced by the South African National Diagnostic Report on Learner Performance in the 2012 final examinations, which highlighted learner struggles with ‘higher order thinking skills such as application, problem solving, critical thinking, analysis and evaluation’ (South Africa DBE 2013: 16). These are skills typically associated with essay questions in examinations. Another issue reported in the above-mentioned document was poorly answered essay questions on Environmental Studies, ‘giving the impression that this topic, which is scheduled towards the end of the year, was neglected by both teachers and learners’ (p. 121). The problem of weak higher order thinking skills, compounded by difficulty with Environmental Studies, informed part of the research interest for this study: namely, how higher order thinking is engaged when reflecting on environmental issues in Life Sciences classrooms (specifically required for the Environmental Studies topic of ‘human impact’).

In Life Sciences, the sub-topic of ‘human impact’ in Grade 11 is supported by a Grade 10 topic of ‘biosphere to ecosystems’, which includes a suggested activity to investigate an ecosystem in a local biome for ‘positive and/or negative human impact on the ecosystem’ (South Africa DBE 2011a: 33). The topic of ‘human impact’ is taught in Grade 11 but (up until 2020) was examined in Grade 12 in the final school-leaving examination. Here, the topic of ‘Human impact on the environment: Current crises for

human survival: Problems to be solved within the next generation' is more detailed, with the specification of causes and consequences of atmosphere and climate change; water availability and quality; food security; loss of biodiversity; and solid waste disposal. The localisation of the topic requires both general and specific knowledge when an activity is suggested to conduct a 'practical observation of ONE example of human influence on the environment in the local area (e.g. the impact of alien species on biodiversity) [and write a] written report on the chosen example' (South Africa DBE 2011a: 51).

It is in understanding environmental issues with social-ecological complexities, such as 'climate change' and 'population ecology', and understanding and responding to 'human impact', that these Life Sciences topics require the higher order thinking skills that are called for in the subject. To gain a more nuanced understanding of the higher order skills listed by the DBE above (application, problem-solving, critical thinking, analysis and evaluation) in the context of environmental learning, this study analysed the development of these skills in relation to the sustainability competencies outlined by Wiek et al. (2011) (see Shumba, Mandikonza and Lotz-Sisitka, Chapter 12). While these competencies were developed by Wiek et al. for the higher education context, we suggest that at the school-leaving level, when learners are expected to discuss the complexity of human impact, these competencies, designed for their role in addressing contextualised and complex 'problem constellations' (Wiek et al. 2011: n.p.) would provide relevant insight. Thus, the study's interest can be elaborated as an interest in how teaching towards the development of sustainability competencies can complement teaching for higher order thinking in environment and sustainability topics in Life Sciences classrooms.

This research interest is reflected in the study's overarching research question:

How can the development and emergence of higher order thinking skills in environmental and sustainability topics in Life Sciences classrooms be complemented by teaching for the development of sustainability competencies?

Competencies in assessment

This section begins by detailing the way in which cognitive levels are outlined in the Natural Sciences Curriculum Assessment Policy Statement (CAPS). This is followed by a description of the sustainability competencies that are used in the chapter, in order to gain a deepening understanding when assessing Life Sciences lessons that focus on environmental topics. Finally, the section draws on critiques of a competence-based curriculum, in order to identify three challenges for a quality approach to competence discourse in school-based assessment practice.

Cognitive levels

In the Natural Sciences CAPS curriculum, guidelines are given as to what types, and the relative weighting, of questions considered to be at low, medium and high

order cognitive levels in: knowing science; understanding science; applying scientific knowledge; and evaluating, analysing and synthesising scientific knowledge (Table 1). The descriptors of the verbs in the table support the identification of cognitive levels in the analytic work of this study, namely in the lesson plans, classroom conversation and assessment tasks.

Table 1. Cognitive levels for the assessment of content in Natural Sciences
 (South Africa DBE 2011b: 87)

Setting tests and tasks for different cognitive levels	Knowing science	Understanding science	Applying scientific knowledge	Evaluating, analysing, synthesising scientific knowledge
Percentages indicating the proportion of low, middle and high order questions in tasks, tests and exams	Low order questions 40%	Middle order questions 45%		High order questions 15%
Useful verbs to use when setting questions	State, Name, Label, List, Define, Describe, and others ...	Explain, Compare, Rearrange, Illustrate, Give an example, Calculate, Make a generalisation, and others ...	Predict, Apply, Use knowledge to demonstrate, Solve, Implement, Judge, and others ...	Select, Differentiate, Analyse, Infer, Suggest a reason, Interpret, Discuss, Categorise, and others ...

These cognitive levels and associated verbs are a useful starting point for thinking about assessment. However, verbs indicating the medium and higher order cognitive levels, especially, are applied differently depending on the type of science one is doing. For example, to analyse data in an experiment is a different process to analysing complex social-ecological phenomena such as those addressed in Education for Sustainable Development (ESD) (see Schudel and Lotz-Sisitka, Chapter 2; Shumba, Mandikonga and Lotz-Sisitka, Chapter 12). In order to obtain a more nuanced perspective on these cognitive levels when dealing with ESD topics, sustainability competencies were used as an additional lens for analysing assessment practice in the classroom.

Sustainability Competencies

De Haan described a competence-based approach to education as an output-focused approach (as opposed to ‘input’). That is, one which ‘asks what problem-solving strategies, concepts and abilities for social action’ a learner should have (De Haan 2006: 22). Wiek et al.’s (2011) model outlining sustainability competencies is relevant for applying knowledge specifically to problem solving in the context of ESD. They argued that sustainability education should enable learners to analyse and solve

sustainability problems, anticipate and prepare for future sustainability challenges, and also to recognise opportunities for sustainability. Because sustainability problems and challenges have specific characteristics, analysing and solving these requires the particular set of interlinked and interdependent key competencies proposed by Wiek et al.

The five competencies central to a sustainability approach to learning were used as lenses for reviewing the development of Life Sciences curriculum competencies in the context of environmental learning. This perspective helped in reviewing learner competencies for working on solutions for real-world sustainability challenges. They are described as follows:

1. Systems thinking and modelling is when a learner demonstrates the ability to analyse sustainability problems cutting across different domains and scales (from local to global).
 2. Anticipatory tracing and imagining (future thinking) is the ability to employ future thinking in sustainability problem solving.
 3. Strategic competence (action-orientated competence) involves activities that can make a sustainable vision happen, including strategic plans for how to mitigate sustainability problems.
 4. Interpersonal engagement and communication or collaboration is the ability to initiate, facilitate and support different stakeholder groups for effective sustainability problem solving. It includes the skills of knowing how to work in teams, communicate, present and facilitate meetings, as well as work effectively with different stakeholders.
 5. Normative competence is the ability to specify, compare, apply, reconcile and negotiate sustainability values, principles, goals and targets, informed by concepts of justice, equity and responsibility in various processes, including visioning, assessment and evaluation.
- (Wiek et.al. 2011)

A critical perspective on competencies

While sustainability competencies are part of international debates in the field of ESD, competence-based education has received some criticism in curriculum debates in the general field of education internationally. There are a number of axes of tension regarding the notion of competencies as they are interpreted and enacted in different ways and with different intentions in different contexts. Drawing on an international perspective regarding the notion of competencies offered by Barnett (1994), and a South African perspective offered by Christie (1997), the authors propose three challenges for a quality approach to competence.

- Responsiveness and transferability of competencies in different contexts (as opposed to a context-bound approach).

- Reflexivity in open-ended problem-solving contexts (rather than employing competencies in an instrumentalist approach to education).
- An integrated (rather than fragmented) approach to knowledge acquisition.

The first challenge – responsiveness and transferability – is important because coping with profound societal and ecological change, locally and globally, cannot simply be covered by the concept of standardised competencies. Competencies are needed that enable learners to respond to sustainability knowledge which is ‘rapidly changing and developing as scientists strive to understand environmental issues better and come up with possible solutions and alternative practices’ (Fundisa for Change Programme 2013: 7). Wiek et al. appear to have responsiveness and transferability in mind when they define competencies as a ‘complex of knowledge, skills and attitudes that enable successful task performance and problem solving with respect to real-world sustainability problems, challenges and opportunities’ (2011: 204).

Implementation of competency frameworks has been criticised for not being able to support responsiveness to new contexts. For example, overly specified competencies have been criticised as being ‘tied to specific contexts and events ... [and] only understandable within that specific context and the material base it rests upon ... Because meaning is context specific, meaning is consumed by that context and can’t easily be applied elsewhere’ (Wheelahan 2007: 639). While this critique comes from a specific vocational education and training context, it has relevance in any educational setting in which problem solving in context is needed. Such a context-bound approach in developing competencies is to be avoided if diverse problem-solving skills in ESD contexts are needed.

In this chapter, we argue that Wiek et al.’s set of five competencies needs to be developed in such a way as to support transference to a variety of contexts in an expansive and responsive manner. Such a view of competencies as transferable is consistent with the view of competencies influencing South Africa in the development of an outcomes-based approach to education. This view of competencies was influenced by an Australian report that described competencies as ‘the ability to apply skills to performing a task, and encompass theoretical understanding of the task, as well as the ability to transfer knowledge, skills and understanding to another context’ (Christie 1997: 56).

The second challenge – that of reflexivity within open-ended problem-solving contexts – relates to Barnett’s statement that ‘we live in an unpredictable age, and corporate life is one of living effectively with continuous change’ (1994: 173). He claims that a competence-based approach to education can represent people and their actions in an instrumentalist way, that is, expecting learners to tackle the world by trying to cope with its challenges, but failing to reflect on problems in the world or form judgements on these. In South Africa, the notion of outcomes-based education has been similarly critiqued for its ‘means-ends’ stance and linear approach to education (Jansen 1998). In this study, reflexive competence is seen as critical for the transformational pedagogies on which ESD relies. Reflexive competence is a competence that builds on practical

competence – ‘demonstrated ability to perform a set of tasks’ – and foundational competence – ‘demonstrated understanding of what we or others are doing and why’. This is in order to ‘integrate or connect performances with an understanding of those performances, so that we learn from our actions and are able to adapt to changes and unforeseen circumstances’ (Gamble 2009: 3).

The sustainability competencies model on which this study relies are not founded on instrumentalist outcomes or linearity, nor do they demonstrate a lack of reflexivity. According to Wiek et al. (2011), sustainability competence (particularly strategic competence) aims to develop students who will be able to design and implement systemic interventions and transformational actions. These interventions, operating in an unpredictable system, necessitate open-ended responses, and therefore overly specified and pre-determined outcomes or competencies cannot be preempted. Additionally, normative competence with its strongly principled, comparative and negotiating features is supportive of reflexivity. Wiek et al.’s approach to sustainability competencies requires that learners look back critically (reflexively) at their own ideas and practices and change them as a result of this reflection (Fundisa for Change Programme 2013: 14).

The third challenge for a competence-based approach is the argument that curriculum competencies should be seen in an integrated rather than reductionist sense (MacFarlane & Lomas 1994). For this study, it is assumed that the five competencies as suggested by Wiek et al. above also specifically guard against reductionism, in that they are a functionally linked complex of knowledge, skills and attitudes. This point is highlighted when the authors describe sustainability competencies as ‘conceptually embedded sets of interlinked competencies’ (Wiek et al. 2011). This interlinking of competencies can be said to be an integration of skills and knowledge around a particular problem in a particular context. De Kraker, Lansu and Van Dam-Mieras (2007: 109) also highlight the importance of integration when working with the notion of competencies, noting that, ‘learning should focus on integrative competences required in professional life, and not on the acquisition of isolated skills and pieces of knowledge’. They emphasise that this is a different perspective on competencies beyond a list of competencies.

The above discussion highlights some of the challenges posed by critiques of a competency-based approach to learning, including limitations to responsiveness and reflexivity, and the danger of fragmentation. However, what becomes evident to us as authors, as the pros and cons of competency frameworks in education are discussed, is that often the problem is traceable to either a narrow interpretation of, or a difficulty with, implementation, rather than any inherent problem in the notion of competence itself.

Research methodology

The study was conducted with four Life Sciences teachers in four schools offering Life Sciences in Grades 10–12 in the KwaZulu-Natal Midlands near Mooi River. All were

farm schools, of which three were no-fee paying and one was a fee-paying school. All teachers were qualified to teach Life Sciences.

The study employed qualitative research methods, namely a questionnaire, stimulated recall interviews, observations (of lesson plan implementation in classrooms) and document analysis (lesson plans, assessment tasks and learners' work) to generate data.

Analysis included descriptions that took cognisance of the following:

- i) Descriptions of high, medium and low order development and achievement in classroom activities and tasks. Each question in the assessment tasks was described as either low, medium or high order. Achievement was described as a percentage for each question. For ease of analysis, achievement was described in three categories: 60% to 100%; 30% to 59%; and 0 to 29%. Six examples of learners' work per classroom were analysed: two whose overall grade was the lowest; two whose overall grade was the class average; and two whose overall grade was the highest. Some tasks did not lend themselves to such a detailed breakdown and these were described qualitatively.
- ii) Emergent sustainability competencies in the environmental learning processes (influenced by Wiek et al. as elaborated earlier).
- iii) A quality engagement with competence influenced by the three critical perspectives on competencies as described above: responsiveness and transferability, reflexivity, and integration.

The results of this analysis are described below in the form of narratives for each teacher and the lessons presented in each classroom. The selected data has been extracted from a more extensive master's dissertation (Mkhabela 2017). The narratives present a holistic perspective on the teachers' intentions as well as the applicable cognitive levels that the assessment practices target in relation to sustainability competencies in each classroom.

Presentation of data

In the first case described, the teacher focused on the topic of population ecology. She began with an exploration of natality, mortality, immigration, emigration and migration which supported the development of **systems thinking competence**. She also aimed at developing investigation skills, namely: following instructions, knowing how to make estimations, performing simple calculations and applying knowledge of theory to practical situations. Evidence of an interest in developing higher order thinking is in her explanation that: *'The problem is calculation, application and interpretation. So, with this lesson I wanted to address these three because I know and have noticed that my learners are struggling on these competencies.'*

During the lesson presentation the teacher tested the learners' ability to explain the logic of the mark recapture method:

Teacher: You took a handful beans and put them back, then now for the first time you were not supposed to close your eyes, but for the second time now you need to close your eyes, why?

Learner: So that I will not take the marked beans only.

These ‘why’ questions are critical for preparing learners for higher order thinking. However, despite the teacher using this questioning strategy in preparing the learners for the assessment task that followed, none of the six learners was fully able to answer the higher order questions about how reliability of the method could be improved, and none could answer a critical thinking question (related to the quoted dialogue above) on why moths should be marked on their ‘underside’. Only one of the six could interpret the data giving a reason for differences in the two populations of moths. This affirmed what the teacher said in the interview when asked about the curriculum competencies of her learners, that: *Basically they [learners] are good at competencies where one word is needed ... They struggle to support the statement to say ‘why are you saying that’.*

With the topic of Environmental Studies, of which ‘Population ecology’ is a part, the CAPS curriculum intends ‘learners to become more informed and more sensitive to environmental issues and to modify their behaviour to lessen their impact on the environment’ (South Africa DBE 2011a: 49). During the lesson, the teacher asked learners to explain the impact of an increase of population on the environment. Learners anticipated that if the population increased, there would be a shortage of houses, water, clean air and food. It is not surprising that this discussion was not conducted in much depth as the quantitative modelling activity did not give them the capital to answer the question. To answer more fully, learners would have required more detail on human-environment relationships (beyond just understanding population dynamics) and more time to research the detail (as learners in the next case were given).

Noticeable, with respect to these competencies, was that there was no **integration** between systems thinking and anticipatory competence. Learners were asked to anticipate a human-environment relationship based on tacit knowledge, while the systems thinking knowledge of population dynamics and quantitative modelling set up as a precursor to the topic of human impact in the curriculum was not helpful in providing the specific systems perspective needed for understanding human-environment relationships.

In the second teacher’s lesson, learners were given a questionnaire to assess their individual carbon footprints and compare differences between their carbon footprints. The carbon footprint calculation activity raised learners’ awareness of their impact on the environment and they compared individual footprints among group members. This supported an aspect of **normative competence** as described above, which is to ‘specify and compare’. This activity would have been good grounding for further development of **normative competence** if, for example, learners had been asked to discuss different ways of reducing their carbon footprint in response to the teacher’s intention of developing learners’ knowledge of how humans negatively impact on the environment, as well as how to counteract these actions.

This footprint task was followed by a task where learners were expected to submit a research report on the impact of humans on the environment. The discussion below of deforestation and the carbon footprint effect preceded this research task and is an illustration of preparing learners for understanding social-ecological systems (**systems thinking competence**).

Teacher: How is deforestation going to affect the level of carbon dioxide (CO₂) in the air?

Learner: By removing trees ...

Teacher: How will it affect the level of CO₂. Is it going to increase or decrease?

Learner: It will increase.

Teacher: Why will it increase?

Learner: It's because trees that use it had been destroyed and CO₂ that human beings exhale would accumulate in the air and no trees to absorb.

Teacher: What other impacts will the rise of human population have on the environment?

Learner: Soil erosion

Teacher: What do you mean?

Learner: The increase of population lead to people building houses even on steep slopes. They remove plants that hold the soil particles together and plants are also destroyed.

This type of discussion, if dealt with in sufficient depth, is the beginning for integrating **systems thinking** (such as the relationship between forests and carbon dioxide and soil stability) and **anticipatory competencies** (what will happen if ...?). Part of the research project mentioned above was for learners to research and report on three examples of human impact in terms of causes, effects and solutions. Four out of six learners achieved above 60% in describing the causes, two out of six achieved above 60% in describing the effects, and one out of six in suggesting solutions. The systems thinking and anticipatory thinking stimulated during the classroom discussion might have supported capacity to describe cause and effect, but the **strategic competence** required to suggest solutions was neither supported during the lesson nor adequately achieved in the assessment task when learners were asked to suggest solutions.

In reflecting on environmental content the teacher commented: *The challenge of environmental content knowledge is, we rely on theory that we get from the textbooks. Teachers and learners will understand environmental content knowledge much better if it is a hands-on lesson.* However, the analysis above suggests that classroom engagement and resources used might be missing content on responses to issues; namely sustainability practices such as policy, conservation and other agential interventions (O'Donoghue, Snow and Misser's Chapter 10 explores important nuances of a problem-solving approach in ESD). Thus, insufficient content coverage could possibly be a more convincing explanation than a lack of 'hands-on' learning.

The third teacher's lesson focused on the topic of human impact, with coverage of the sub-topic – 'water quality and availability'. With this topic, the CAPS curriculum intends to 'emphasise the interrelatedness and interdependence of human impacts and the environment' (South Africa DBE 2011a: 51). The teacher intended learners to look at the causes and consequences of problems with water quality and availability as well as solutions to these problems. Learners were taken on a field trip to a local river to observe and discuss human influence on water quality at different points in the river between a weir and another point, eight kilometres downstream. E-coli measurements had been arranged by the teacher in preparation for the trip. As an assessment task, learners completed a worksheet. In the worksheet, one learner demonstrated **systems thinking** by noting:

They release hot water in to the dam. It is not the long-term problem but it affects the living things in the water. In the sewage farm, the use of chlorine to clean the water kills bacteria but not the metals, batteries and all the other chemicals that get flushed down to the toilet. There were also lot of sewage leakage that come flow straight into the river from Bruntville, the E. coli count was 1500 per million at Helen's bridge.

The extract above demonstrates **anticipating** the effect on living things through thermopollution. Anticipatory thinking was also demonstrated when a learner commented that diseases like cholera might occur due to poor water quality (risks). The teacher followed by adding that: 'It can be any type of diseases because lot of kids play here.'

Solutions in the worksheet demonstrating competence for thinking **strategically** included:

People need to be educated by the municipality about the importance of water and the municipality must monitor the condition of the river frequently working closely with uMngeni water board. Another specific comment was: We can prevent this by revamping smaller pipes into bigger ones and restrict dumping from water.

However, learners did not perform well regarding strategic thinking, all of them receiving between 30% and 60% for this question. The above extract also demonstrates the foundations (if not reflexive realisation) of **interpersonal competence** which is described above the ability to initiate, facilitate and support different stakeholder groups in developing sustainability competence.

For the worksheets, all six learners achieved more than 60% for higher order questions that required:

- An analysis of water quality at the weir and at a second point further downstream.
- A discussion of the ecological impact of dams.

Fewer learners (four) achieved at more than 60% for a higher order discussion on the effects of the following on water quality: (a) Exotic trees, (b) Destruction of wetlands, (c) Poor farming practices and (d) Irrigation. This suggests that at least two thirds of the class were developing the **systems thinking competence** needed for discussing social-ecological complexities of environmental issues. In a final question where learners were expected to discuss water management and solutions to the problems (**strategic competence**), no learners achieved at above 60%, thus demonstrating a difficulty in **transferring** of strategic competence to a different context.

Significantly, the curriculum emphasises cause and consequence explicitly, but ‘solutions’ are only mentioned implicitly with respect to some of the proposed human impact topics (not within the water quality sub-topic). For example, under the biodiversity loss sub-topic, the curriculum suggests looking at ‘indigenous knowledge systems and the sustainable use of the environment’ (South Africa DBE 2011a: 52). In this respect, the teachers’ explicit interest in solutions as described above was a useful refinement and extension of curriculum content from an environmental perspective.

The rationale for the field trip method used by the teacher was: *‘The use of DVDs and textbook put a barrier between learners’ lives and the problem, but if they see what is happening in their area, it becomes real.’* This point supports the teacher’s argument in the above case that practical work is important for environmental studies and can support a **responsive** approach to competence. Also, in this case, the fairly high levels of achievement (compared with the other lessons discussed) illustrate how field work can support achievement of higher order thinking. Yet, as in the above case, it does not explain why the higher order thinking skill of ‘finding solutions’ appears to be difficult for some learners.

The formal assessment task was a test addressing different aspects around sustainability challenges and learners were expected to suggest reasons and solve environmental problems. Knowledge of different aspects of human influence on the environment was assessed, such as ozone depletion, greenhouse effect, global warming, and over-utilisation of natural resources. Mkhabela (2017) includes a full analysis of the test, but it is worth noting here that one of the higher order questions from the test that related to water, which was: ‘Water quality is rapidly becoming a more critical problem than water availability in South Africa. Why is this the case?’ was achieved at above 60% by two of the learners, between 30% and 60% by two learners and less than 30% by two learners. This implies that the field trip had not necessarily prepared learners to achieve higher order thinking as successfully in a written test as they had achieved in the field trip worksheet and indicates that the **transferability** of competence displayed during the field trip activity was not necessarily achieved.

The fourth teacher’s lesson was also about human impact on the environment, with a focus on the sub-topic ‘food security’. He gave learners the local newspaper and asked them to discuss an article in which local farmers raised concerns about veld fires and drought and the impact of this on food production. Learners were divided into six groups and asked to discuss and develop a presentation on one of the following:

- The impact of exponential growth on food availability.
- How natural environmental occurrences can impact on food security.
- How the agricultural sector impacts on food security.
- How fuel and food price increases, poverty and monopoly of seed production could contribute to food insecurity.
- Intervention measures to address the problem of food insecurity in South Africa.

During presentations, the teacher and learners analysed a sustainability problem (food security) by discussing the dynamics across multiple domains. These domains were: exponential increase of human population; occurrences such as droughts, floods, climate change (ecological); the rise of petrol and food prices (economy); and the use of fertilisers by farmers (technology) which are related to food security (**systems thinking**). During discussions, learners anticipated that as the human population increases, poverty and high unemployment rates would be experienced (**anticipatory competencies**). However, the anticipatory competence demonstrated in this discussion did not necessarily realise the full complexity of the systems thinking developed during the presentations. This indicates that a greater integration between systems thinking and anticipatory competence might strengthen the higher order thinking needed for understanding the problem of food insecurity.

As a formal assessment task, learners were given an assignment to research how the Chimanimani people in Zimbabwe use permaculture farming to mitigate against food insecurity. In the formal written task, learners were expected to conduct a higher order discussion about the Chimanimani community's engagement with issues of sustainable food security as well as ways to enrich the soil. This task was mainly unsuccessful in terms of learning outcomes as all but two learners cut and pasted their entire answers from an internet site. Only two of the learners presented original work by creating their own arguments from internet-based research. This indicates that because higher order thinking often requires creative thinking in terms of analysing and discussing, it needs to be supplemented with formative support for meta-cognitive skills such as learning how to research and how to construct original arguments.

Of the two learners that were able to construct original arguments, the argument by one of the learners on the importance of engaging in collaborative decisions (as illustrated in the Chimanimani case study) revealed the potential of such case studies to raise foundational understanding of **interpersonal competencies**. Another learner reported how the community acted to retain spring water by planting trees on the hilltop catchment (foundational for **strategic competence**). This learner also reported how community members developed permaculture gardens for the elders and orphans. This showed learners' consciousness of the sense of responsibility among community members and indicated potential for developing foundational understanding of **normative competence**. Significant in this lesson was that all five sustainability competencies were integrated across the two tasks.

Discussion and Recommendations

Understanding human impact requires sustainability competencies

Looking across the four cases outlined above, the findings indicate that CAPS Life Sciences environmental studies content knowledge, and particularly the topic of human impact, requires higher order thinking skills such as analysis, discussion of complex social-ecological phenomena, and problem solving. In implementation, this topic also seems to require all five sustainability competencies.

In all four lesson presentations, systems thinking and anticipatory competencies were supported and they appear to have been effectively integrated in two of the four schools (Teacher 2 and Teacher 3 lessons). In these two schools, it appears that these competencies were supporting learners 'to become more informed and more sensitive to environmental issues' (South Africa DBE 2011a: 49). Where there was no **integration** between competencies, the ability of learners to demonstrate understanding of sustainability challenges was compromised. This occurred in the first case, which did not build understanding of social-ecological complexity, and in the fourth case where social-ecological understandings from the first part of the lesson were not brought into the anticipatory discussions in the second part of the lesson.

In three of the lessons, learners were expected to extend systems thinking and anticipatory competence and draw on strategic competence to research a range of issues (in the case of Teacher 2's research project), look at how others had resolved environmental problems (in the case study of the Chimanimani), or think hypothetically about how the problems of water pollution could be resolved (in the case of the field trip). Strategic competence was demonstrated by only one learner in the research report; it was attempted in the field trip worksheets but not achieved at a satisfactory level of performance, and was demonstrated in the form of foundational understanding by a limited number of learners reporting on the Chimanimani case.

Normative competence (to a limited degree) was only addressed in one of the cases. However, without the **reflexivity** of a more extensive engagement in **normative** competence (which could have been achieved through thinking about ways to reduce their respective carbon footprints and/or through thinking about resolutions to environmental issues), learners were not supported in the curriculum intention to 'modify their behaviour to lessen their impact on the environment' (South Africa DBE 2011a: 49). We suggest that the features of normative competence, such as negotiation, reconciliation and visioning, as elaborated earlier, are important in problem solving to respond to this need to 'lessen impact'.

Interpersonal competence was foundational for understanding the role of stakeholders in sustainability practices, in response to problem situations highlighted during the field trip (the role of educators and the municipality were highlighted) as well as in the Chimanimani case study (the role of community partnerships was highlighted). The curriculum emphasis on modifying learners' individual behaviour, as noted above, is a significant limitation in supporting the development of such interpersonal competence.

We suggest that for more effective problem solving, the curriculum needs to call for a deeper understanding of agency and change beyond individual behaviour.

Strengthening higher order thinking in ESD contexts

While the cases described in the results demonstrated an intention, as well as some successes, to develop higher order thinking, there are also some lessons that can be learned from these cases that might enable the strengthening of higher order thinking in Life Sciences classrooms. The questioning strategy used by Teacher 1 in the classroom appears to be leading learners to the right kinds of thinking; however, their struggles with formal tasks suggests that even more classroom time needs to be spent on formative assessment for the purpose of developing higher order thinking, and more time responding to ‘why’ questions in different forms and different ways. Another important aspect of formative classroom work appears to be the need for focusing on developing meta-cognitive skills such as researching and constructing arguments, as implied by the difficulty learners had with Teacher 4’s research task.

There appear to be some contradictory suggestions in the evidence regarding the importance of practical work in developing understanding of environmental issues. While learners generally performed well in Teacher 1’s practical activity, this did not necessarily lead to performing well with higher order thinking skills, nor with the human impact question asked of them as a follow on. Similarly, with the field work task, learners performed fairly well in answering some of the higher order questions but were not as successful in the problem-solving questions either in the field trip worksheet or the test that followed. Thus, the data suggests that practical work needs to be supported by appropriate content coverage in order for higher order thinking to be strengthened, and that teachers should be careful of an over-reliance on tacit knowledge regarding full understanding of complex environmental issues.

Above, we discussed the lack of integration between systems and anticipatory competence in the first case. In this regard, we suggest that curriculum developers need to consider whether the topic of population ecology is the best lead-in to the topic of human impact, in order to develop understandings of such social-ecological relationships and how this may lead to a fragmented approach underpinning the topic of human impact. One teacher indicated the usefulness of drawing on Grade 10 ecological understandings to support understanding of the human impact topic. Thus, progression in the lead up to the topic of human impact appears to be an important point for review in the curriculum and teacher training (see Mmekwa and Schudel who trace how problems with progression arise, Chapter 3).

In the discussion on competencies in the section above we suggested that work on competencies needs to take heed of a number of challenges before it can be seen to support quality learning. These include responsiveness and transferability, reflexivity, and integration. Reflexivity and integration have been discussed in the previous section. Regarding responsiveness and transferability, the best examples to draw on were cases 3 and 4, because they moved from responding to local contexts, to general and specific

‘neighbouring’ contexts. Teacher 3 moved from a study of a local river to a test about a variety of environmental issues. It was pleasing to see that learners achieved well in higher order thinking (60% and above) for both the local task and the test. In a different shift, Teacher 4 moved from studies of environmental issues in local newspapers to a Zimbabwean case study in a neighbouring context. Even though learners did not generally perform well in the case study, the two teachers demonstrated different teaching methods that can be designed to help learners in transferring competencies from local to general application and from one context to another.

Summary and conclusion

This study has shown that the section on Environmental Studies in the Grade 11 curriculum (which includes ‘population ecology’ and ‘human impact’) requires higher order thinking skills such as analysis, problem solving and discussion. It suggests that social-ecological systems thinking (beyond the thinking developed by population ecology) is important for fully understanding environmental issues and that curriculum progression is an important consideration in building this thinking. The study also illustrates how the three challenges to competence-based approaches to learning play out in classroom contexts. First, social-ecological systems thinking is important to bring forward in an integrated way in supporting extended sustainability competencies. Second, we suggest that strategic, normative and interpersonal thinking needs strengthening in classroom situations as part of a reflexive approach to competence development, especially where finding solutions to environmental issues is important. Engaging in content around sustainability practices (as opposed to problem contexts only) can be an important springboard for developing these competencies. Third, the study indicates that transferability of competencies is not automatic when moving from local studies to general contexts or different contexts. It suggests that even though engaging different contexts through different teaching strategies shows promise, salient content (especially regarding solutions to issues) needs to be developed to support the problem-solving needs in ESD contexts. Pedagogical suggestions from the study are that teachers need to continue using questioning strategies in the classroom to build learners’ experience and confidence in answering higher order questions in formal assessment tasks, and that meta-cognitive skills are also important considerations for developing higher order thinking.

Overall, this study has shown that environmental topics, especially those with an emphasis on human impact (and the natural extension into sustainability practices) require higher order thinking skills such as analysis, problem-solving and discussion. It suggests that taking cognisance of sustainability competencies can strengthen the development of these skills. It is hoped that the knowledge about the relationship between environmental content, higher order thinking, and sustainability competencies developed in this chapter will be of value to assessment thinking in other subjects and other environmental topics, as well as to other countries working either with competence-based or content-based curricula.

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