An Investigation of the Usage of Teaching Methods and Assessment Practices in Environmental Learning Processes and Emergent Curriculum and Sustainability Competencies

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ABSTRACT

This study explores the teaching and assessment practices used by teachers in environmental learning processes and emergent curriculum and sustainability competencies. The focus is the school subject Life Sciences in the Further Education and Training Phase. The study is based on four cases of teachers in schools in the Midlands area, in the province of KwaZulu-Natal.

Lenses used to review the data included curriculum defined cognitive skills and cognitive levels to review the curriculum competencies and a systems approach to teaching and learning (Wiek, Withycombe, Redman & Mills, 2011) to review emergent sustainability competencies.

This study employed qualitative methods, namely a questionnaire, stimulated recall interviews, observations (of lesson plan implementation in classrooms) and document analysis (detailing lesson plans, assessment tasks and learners' work) to generate data. Analysis took place in four phases and included: a descriptive contextual analysis of factors influencing teaching and assessment practices; a descriptive analysis of teacher intentionality, topics, assessment planned and resources used; an analysis of emergent curriculum competencies in informal and formal assessment tasks; and, finally, a second layer of analysis describing emergent sustainability competencies in the environmental learning processes. Ethical considerations included permission for access, anonymity, participant rights and awareness of my role as cluster leader for the group of teachers involved.

The study found that the nature of Life Sciences environmental topics and implementation influences the development of curriculum and sustainability competencies. Also, the choice of teaching methods influenced the emergence of particular curriculum and sustainability competencies. The findings also suggested that switching between isiZulu and English, unfamiliarity with action verbs, and the inconsistent use of higher order questions in classroom discussion, informal and formal assessment tasks might have affected success in the development of higher order thinking skills. Finally, the study revealed that environmental learning has the potential to support the development of integrated sustainability competencies.

This study was driven by an interest in environmental content knowledge, teaching and assessment within the South African Fundisa for Change network of environmental educators. It is hoped that the study's illustration of how consideration of curriculum and sustainability competencies can contribute to quality education practices in environmental learning, will be of use in this network.

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CHAPTER 1: INTRODUCTION AND CONTEXT

1.1 Background and context

After South Africa's first national democratic election in 1994, there was a need to reform education in order to overcome the curricular divisions of the past. The White Paper on Education and Training (1995) stressed the need for major changes in education and training in South Africa in order to standardise and transform teaching and learning. It explicitly called for the integration of environmental education and adoption of an active integrated approach to teaching and learning. It required the integration of environmental education for sustainable development into all levels and phases of the education system. A new curriculum 2005 (C2005) was pronounced in 1997, that replaced a pre-democracy content-based curriculum with outcome-based education (OBE). A 2009 national curriculum review (Chisholm, 2000) reported a number of problems that had been experienced with C2005. For example, the report noted that there was a lack of content knowledge, assessment requirements were not clarified and the main methodologies used by teachers in C2005 for teaching and learning were facilitation and group work (South Africa. Department of Basic Education [DBE], 2009). The revision of C2005 led to the introduction of the Revised National Curriculum (RNC) which was completed in 2002 and implemented in 2004.

The introduction of the NCS led to the development of Subject Frameworks and Subject Assessment Guidelines which outlined how to plan for teaching as well as how to assess. Greater clarity around content and assessment was provided in the policy. Although the NCS stipulated the content to be taught and the assessment standards, it lacked clarity on what teachers were required to teach from grade to grade (South Africa. DBE, 2009).

The curriculum review led to the introduction of the Curriculum and Assessment Policy Statement (CAPS) which explicitly outlined assessment requirements and the content knowledge to be taught in each grade (South Africa. DBE, 2011a). Although CAPS has streamlined content, concepts and skills progression as mentioned above, it lacks prescribed methods teachers can use in mediation of their lessons. According to CAPS, "educators have the freedom to expand concepts and to design and organise learning experiences according to their local circumstances, including the availability of resources" (ibid., p. 10). This study focuses on the methods and assessment practices used in Life Sciences classrooms to explore

how curriculum and sustainability competencies are being developed in the learning processes.

The study draws on Wiek, Withycombe, Redman and Mills (2011) who have developed a model outlining sustainability competencies that are appropriate when applying knowledge specifically to problem-solving in the context of Education for Sustainable Development (ESD). Because of the emphasis on environmental studies in the Life Sciences curriculum (Knowledge Strand 3), the work by Wiek et al., with an emphasis on competency in an environment and sustainability context, seems to be an appropriate lens to review curriculum competency in this study.

1.2 Research question and goals

The research question guiding this study is:
How are teaching methods and assessment practices used to develop curriculum and sustainability competencies in environmental learning practices?

The goals of the research are:

1. To investigate the local contextual factors influencing classroom teaching and assessment practices.
2. To investigate curriculum planning, teaching and assessment practices.
3. To investigate the development and emergence of curriculum competency in informal and formal assessment in environmental learning.
4. To investigate the emergence of an integrated approach to developing sustainability competencies in environmental learning processes.

1.3 Motivation for the study

Motivation for this study came from the 2013 annual examiners' report. This report highlighted learners' challenges in Life Sciences matriculation examinations, with achieving the curricular competencies of developing lifelong skills and attitudes. Such competencies include application of knowledge, evaluation, synthesis and analysis (National Diagnostic Report, 2013). These are competencies typically associated with higher order questions in examinations, and competencies closely associated with the sustainability competencies developed through environmental learning (see Section 2.11).

My personal motivation for this study is that I am a Grade 10 to 12 Life Sciences teacher, teaching environmental and sustainability content knowledge to those who have passion and interest in environmental education. I am involved in environmental projects including Eco-Schools, the School Environmental Education Programme (SEEP) and Cranes in the Classroom offered by the KwaZulu-Natal Crane Foundation. The GAP roadmap and a further personal interest in exploring educational methods as well as assessment practices that respond to the need for developing higher order thinking skills, has inspired my interest in exploring these practices in the context of environmental learning.

1.4 Research site and participants

The study was conducted in four schools offering Life Sciences in Grades 10-12 in the KwaZulu-Natal Midlands area. All of them were farm schools, of which three were non-fee paying and one was an ex-model C fee-paying school. Teaching staff numbers at the schools ranged between 8 to 21 teachers with learner enrolment ranging from 80 to 690 learners. The teacher-learner ratio ranged from 1:12 in the ex- model C school to 1:40 in the other three schools. English was the language of instruction. Three teachers taught Zulu-speaking learners and the fourth taught learners who spoke a variety of different home languages (Afrikaans, English, Sotho and Zulu) in the ex-model C school.

Two teachers' home language was isiZulu, one was Shona and one was English. Four teachers, one from each school were involved in the study and all were teaching Life Sciences in Grades 10 to 12. These teachers all participated in a Life Sciences ward cluster of which I was the coordinator at the time of the study. All four teachers were qualified to teach Life Sciences. Three had Bachelor of Education degrees and one had a teacher's diploma. Teaching experience and teaching of Life Sciences ranged from 5 to 28 years, three teachers having taught Life Sciences when it was still termed Biology prior to the implementation of the NCS (Pandor, 2006).

1.5 Overview of the study

This first chapter has given a brief introduction to the study and described the national educational context and the international Education for Sustainable Development context of the study. This was followed by the research question and goals. My own role and interest as well as the research site and participants were also discussed.

Chapter 2 reviews relevant literature on environmental education within the curriculum in the global, regional and national context. The chapter also outlines the conceptual and theoretical frameworks of the study (sustainability competencies) drawing from Wiek, Withycombe, Redman and Mills (2011).

Chapter 3 is a description of the research methodology. The chapter discusses the interpretive case study method deployed and methods of data generation and analysis. The chapter also discusses ethical issues, validity and trustworthiness of the study.

Chapter 4 presents the data generated for the four cases from the questionnaire, lesson observations, stimulated recall interviews, assessment tasks and learners' work.

Chapter 5 discusses the findings, recommendations arising from the research study and recommendations for further research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature on the background of environmental education in South Africa, as well as curriculum changes in relation to environmental education in Curriculum 2005, the National Curriculum Statement and the Curriculum and Assessment Policy Statement curriculum. It further reviews literature on pedagogic approaches to environmental education to help in understanding the implementation of teaching methods and assessment practices in developing CAPS curriculum competencies. In addition, literature on sustainability competencies in the context of ESD is reviewed.

2.2 Background of environmental education in South Africa

South Africa held its first international conference on environmental education in 1982 at Treverton College, Mooi River in KwaZulu-Natal, which resulted in the establishment of the Environmental Education Association of Southern Africa (EEASA). In 1992, EEASA coordinated a policies and procedures survey in response to a call to develop an education curriculum policy within formal education. This resulted in the establishment of the Environmental Education Policy Initiative which then called for the establishment of the Environmental Education Curriculum Initiative. In 1994 the African National Congress government realised that South Africa was confronted by serious economic, social, political, cultural and environmental problems. In response to these problems, a socio-economic policy framework, the Reconstruction and Development Programme (RDP) was tabled (South Africa [SA], 1994). One of the roles of the RDP was to ensure that all South African citizens, present and future, have the right to a decent quality of life through sustainable use of resources.

The White Paper on Education and Training (1995) stressed the need for major changes in education and training in South Africa in order to standardise and transform teaching and learning. It further stated that environmental education should adopt an active integrated approach to teaching and learning (SA, 1995). That meant that methods used should engage learners in activities within lessons with active learning. A principle in this White Paper noted that:

> environmental education, involving an interdisciplinary, integrated and active approach to learning, must be a vital element of all levels and programmes of the

> education and training system, in order to create environmentally literate and active citizens and ensure that all South Africans, present and future, enjoy a decent quality of life through the sustainable use of resources. (p. 18)

The EECI which operated from 1996 – 2000 (EECI, 2000) played a key role in ensuring the inclusion of environmental education as a cross-curricular concern in C2005 (South Africa. DBE, 1997). This led to the defining of environment as a cross-curricular phase organiser in C2005 which required all teachers, in all learning areas, to consider an environmental focus. Each learning area had a particular environmental focus embedded within it.

Frohlich (2006) and Lotz-Sisitka, Olvitt, Gumede and Pesanayi (2006) noted that Southern Africa's environmental problems (socio-ecological issues) include poverty, biodiversity loss, global climate change, unemployment, ozone depletion and water scarcity. According to Ketlhoilwe (2010), the implementation of environmental education in Botswana needs teachers to have a deeper understanding of what is required and how to implement environmental learning in particular contexts.

Rosenberg (2008) reported that most schools in South Africa are in the former homelands, with inadequate resources. Rosenberg further noted that education policies are focused on addressing a past inequality, on the relevance of curriculum content, but implementation is falling short as some schools are characterised by lack of discipline, lack of motivation as well as poverty. According to Loubser (1997), Ketlhoilwe (2003), Ketlhoilwe (2007) and Hogan (2008), some of the factors that influence the mediation of environmental learning in Southern African schools are a perceived lack of funds and lack of educational resources.

Rosenberg (2008) noted the significance of motivation and support by non-governmental organisations such as the Eco-School programme, initiated in 2003 by the Wildlife and Environment Society of South Africa (WESSA), in improving the quality and relevance of environmental education. The programme improves learner motivation, provides resources to support teaching and learning, improves teacher competence and manages curriculum and delivery. This study is focusing on methods and assessment practices in environmental learning in the CAPS curriculum. For this initiative, it has been important to investigate how teachers teach and assess the environmental content in the curriculum. The following section will look at curriculum changes in South Africa in relation to changes in teaching methods

and assessment practices in environmental content knowledge across the three curricula namely C2005, the NCS and the CAPS.

2.3 Significant changes in relation to environmental content, teaching methods and assessment practices in C2005

With the introduction of Curriculum 2005 in South Africa, integration became a key feature of lesson planning and teachers were expected to integrate across learning outcomes and across learning areas. However, it was noted that in practice, a problem with the cross-curricular approach to environmental learning was that the focus on a cross-cutting theme tended to detract from furthering the "aims of the learning area" and "deepening of knowledge or process skills from specific learning areas" (Lotz-Sisitka & Raven, 2001, p. 61). Thus, C2005 trivialised content knowledge by threatening to atomise and fragment curriculum knowledge when topics on environmental education were identified, singled out and taught separately (Holland, 1994). By organising knowledge around discrete disciplinary demands encountered in learning a complex task, C2005 was criticised for knowledge that was "thin, interspersed and inconsistently presented" (Dada et al., 2009, p. 45). This concern was consistent with reports from environmental education research that teachers experienced difficulties with finding and contextualising relevant content knowledge (Schudel, 2010) and experienced difficulties with their own unfamiliarity with environmental concepts new to their frame of reference (Lotz-Sisitka, 2009).

C2005 emphasised group work as a method of teaching and learning where learners were left to construct their own knowledge without the teacher's mediation of new content knowledge (Dada, Dipholo, Hoadley, Khembo, Muller & Volmink, 2009). The teacher's role was to facilitate group work as learning outcomes were favoured over content and a learner-centred approach over a teacher-centred approach (Chisholm, 2000; Harley & Wedekind, 2004). In South Africa, environmental teachers working with Curriculum 2005 reported that teachers had difficulties with selecting and adapting activities that made appropriate links with learning outcomes and assessment standards. Teachers also had challenges in designing assessment activities that would enable them to judge how well knowledge, skills, attitudes and values had been met (Mambinja, 2008; Ncula, 2007; Schudel, 2006). C2005 emphasised continuous and criterion-referenced assessment where mastery of learning was competence-based (Spady, 1994).

2.4 Significant changes in relation to environmental content, teaching methods and assessment practices in the NCS

The C2005 revision led to the NCS which focused on promoting a greater emphasis on subject-related content-based knowledge. This was in order to balance out an over-emphasis on outcomes and integration which characterised C2005 (Lotz-Sisitka & Janse van Rensburg, 2000). One of the principles that underpinned the NCS curriculum was the recognition of the relationship between social justice, a healthy environment, human rights and inclusivity (NEEP-GET, 2004). This principle had been extended to the Further Education and Training band (FET) where a strong focus on environmental justice is integrated into all subjects. In South Africa, education is broadly aimed at ensuring that learners acquire and apply the ability to identify and solve problems and make decisions using critical and creative thinking. It further aims at "producing learners who are able to demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation" (South Africa. DBE, 2011a, pp. 4-5).

The NCS was concerned with the attainment of assessment standards, as shown by this extract from Life Sciences NCS curriculum:

> Content and context are provided to support the attainment of the Assessment Standards. The content indicated needs to be dealt with in such a way as to assist learners to progress towards the achievement of the learning outcomes. Content must serve the learning outcomes and not be an end itself. The assessment standards and not the knowledge areas determine the depth or level. The criteria used to select core knowledge and concepts were derived from the learning outcomes and assessment standards, as well as the principle underpinning the NCS. (South Africa. DBE, 2003, pp. 32-33)

This curriculum was further reviewed and replaced by the new curriculum called CAPS.

2.5 Significant changes in relation to environmental content, teaching methods and assessment practices in CAPS

The CAPS curriculum was implemented in 2012 with a strong emphasis on content knowledge as an important foundation for learning. This was influenced by the 2009 national review which highlighted that the "key dimension related to the successful implementation of curriculum relates to the detail and clarity provided by policy in relation to what to teach"

(Dada et al., 2009, p. 47). The focus on content knowledge and specified assessment within a further streamlined curriculum was shared by the South African Minister of Education when introducing new CAPS documents to the public: "The intention is to streamline the curriculum documents into single documents for each Grade and each subject in which content and assessment are specified" (Motshekga, 2010, p. 6). The CAPS curriculum expects teachers to help learners to recognise the links between related topics so that they acquire a thorough understanding of the nature and interconnectedness of life (South Africa. DBE, 2011a, p. 10).

The reason for focusing on environmental content in this study is the statement that inadequate attention is being given by teachers to this knowledge area (environmental and sustainable development knowledge) which is essential for improving the quality and relevance of teaching in South Africa (Lotz-Sisitka, 2009). The 2013 examiners' report concurs with the statement above explaining that "generally questions on environmental studies were poorly answered giving the impression that this topic, which is scheduled towards the end of the year, was neglected by both teachers and learners" (National Diagnostic Report, 2013, p. 121).

In Life Sciences CAPS, the content framework is organised according to four 'knowledge strands', which are developed progressively over the period of three years of the FET phase (South Africa. DBE, 2011, pp. 9-10). The four knowledge strands are:

Knowledge Strand 1 – Life at a Molecular, Cellular and Tissue Level
Knowledge Strand 2 – Life Processes in Plants and Animals
Knowledge Strand 3 – Environmental Studies
Knowledge Strand 4 – Diversity, Change and Continuity

The curriculum states that the topics in each knowledge strand "should not be studied separately or independently" and that "it is very important to help learners to recognise the links between related topics so that they acquire a thorough understanding of the nature and interconnectedness of life" (South Africa. DBE, 2011a, p. 10). The curriculum document also states that the links between topics should also be made across Grades (ibid.). The curriculum indicates that learning is not simply about knowledge transmission in its statement that "content framework focusses on ideas, skills and concepts as well as connections between them rather than on listing the facts and procedures that need to be learned" (ibid.: 10). This requirement has implications for assessment as well.

The focus of this study is on knowledge strand three (environmental studies) particularly to explore how the environmental content knowledge is taught, assessed and contributes to developing curriculum and sustainability competencies. While the CAPS curriculum claimed to have more structured content "in which content and assessment are specified" (Motshekga, 2010, p. 6), such structured content, referred to above has the potential to narrow opportunities for environmental learning. The topic "human impact on the environment: current crises" in Environmental Studies in the Life Sciences CAPS document highlights the problems to be solved within the next generation. (South Africa. DBE, 2011a, p. 51). For example, the Life Sciences CAPS document specifies an interest in the emphasis of the interrelatedness and interdependence between humans and the environment (with content emphasis on causes and consequences of atmosphere and climate change, water availability and quality, food security, loss of biodiversity and solid waste disposal). However, content coverage does not extend to mitigation considerations related to such human activities nor encourage learners to take action in solving problems caused by such activities. Learning about cause and effect only, does not engage learners fully with the full body of knowledge regarding environmental issues. This limitation reflects the "dominant knowledge practices … in environment and sustainability-related teaching" described by Lotz-Sisitka as tending to be "limited by content on problems and issues for raising awareness, and [failing] to develop conceptual depth and understanding of environment and sustainability" (2011, p. 30).

Monroe and Kaplan (1998) observed that action projects are often not carried out in schools, as they entail a variety of constraints including lack of materials to guide the process and short class periods. Cotton (2006) highlighted that action projects provide knowledge, skills, awareness and creative thinking in learners. They also develop ownership and pride in their schools, a point made by Rosenberg (2008): linking environmental projects with curriculum learning provides teachers with opportunities to bridge between everyday knowledge and experiences of learners and the formal knowledge required by the curriculum. Lee (1997) also observed that 'learning by doing' is recommended for learners to acquire knowledge, skills and attitudes through practical and applied activities.

Even though the CAPS document states that "… educators have freedom to expand concepts and to design and organise learning experiences according to their local circumstances, including the availability of resources" (South Africa. DBE, 2011a, p. 10), the concern is whether all educators are knowledgeable enough to "expand" beyond given content knowledge specified in the document.

Taylor and Vinjevold (1999) reiterated the importance of content knowledge in the curriculum by stating that when learners do not have a strong foundation of content knowledge, they are unable to develop systematic understanding of ideas. They highlighted that learners should acquire a high level of content knowledge and problem-solving skills. This demands a depth and sophistication in teachers' grasp of academic subjects.

Summers, Kruger and Childs (2001) are of the view that teachers need wider and deeper knowledge than that required by learners for responding to learners' needs and dealing with unforeseen questions. This means that teachers should have a deep understanding of content to develop sustainability competencies. The following topic looks at the methods that can be employed by teachers to meaningfully teach the content to learners.

2.6 Teaching methods

The CAPS curriculum aims to ensure that learners acquire and apply knowledge and skills in ways that are meaningful to their own lives (South Africa. DBE, 2011a, p.4). As such, the current South African National Curriculum Statement Grades R-12 aims to produce learners that are able to:

- Identify and solve problems and make decisions using critical and creative thinking;
- Work effectively as an individual and with others as members of a team;
- Organise and manage themselves and their activities responsibly and effectively;
- Collect, analyse, organise and critically evaluate information;
- Communicate effectively using visual, symbolic and/or language skills in various modes;
- Use science and technology effectively and critically showing responsibility towards the environment and the health of others; and
- Demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation. (South Africa. DBE, 2011a, p.5)

The above are the overarching aims which all teachers are expected to achieve across subjects they teach. While methods for achieving these aims are not specified, the implications are for methods that develop critical and creative problem solving capacity in both individual and collaborative work, drawing on important organisational and communicative skills in

response to society's needs and challenges. There are also implications for assessment and for the need for developing higher order thinking skills.

The South African White Paper on education states clearly that environmental education should adopt an active integrated approach to teaching and learning which is in line with CAPS curriculum that encourages an "active and critical approach to learning instead of rote learning which does not create opportunities for critiquing of given truths" (South Africa. DBE, 2011a, p. 4). Active learning is interpreted by the Fundisa for Change Programme (2013) as requiring learners to engage actively with complex social and ecological concepts, issues and risks relating to local and global contexts. This suggests that learners should be given opportunities to critique and evaluate content, concepts and issues introduced to them. This is important as they are working with environmental content knowledge which is contested. Environmental concerns are often complex and contested, so learners need to engage critically with these issues. Teachers therefore need to develop the capacity to design teaching and learning interactions that encourage critical thinking and analysis of topics at different scales and in different contexts (Fundisa for Change, 2013, p. 11).

The reason for focusing on teaching methods in this study is to explore teaching strategies used by teachers to provide learners with opportunities to acquire the knowledge, understanding and skills required to engage effectively with environmental issues, including those of sustainable development. In this study methods are also considered with respect to whether they cater for the aims of the NCS mentioned above.

Lotz-Sisitka and Raven (2001) have stated that for learners to acquire diverse skills, active learning strategies should be used, that is critical thinking and involvement in real issues (authentic learning). This implies learning about real environmental threats and problems, and looking for real solutions to these challenges. In authentic environmental learning, teachers use local, community sources of information, community newspapers, resources, organisations and indigenous knowledge available in the community. Authentic learning helps learners to understand the interaction of environmental, social and economic processes and cope better with the complexity of sustainable development (Guarevitz, 2000).

Ketlhoilwe (2010) indicated that in Southern Africa, the implementation of environmental education demands a review of current epistemological and pedagogical practices.

Ketlhoilwe (2003) supported the use of learner-centered, participatory and active learning methodologies when teaching environmental content knowledge.

According to Kostova and Atasoy (2008), successful environmental learning depends on the teaching and learning methods used. They argued that a combination of teaching and learning methods oriented towards agency, capabilities and social and structural changes are likely to achieve environmental education objectives. Examples of these methods are role play, active learning, investigation, experiential learning, group work, presentations, discussions, debates, field work, homework studies, demonstrations, observations and collaboration. Loubser (2008) emphasised that effective teaching of environmental education should move away from teaching and learning based solely on transmission of knowledge. He also supports learner-centered approaches for stimulating and maintaining learners' interest in the environment. However, Uugwanga (1998) and Ketlhoilwe (2003) noted that large class sizes make it difficult for group work and other learner-centered activities to teach environmental learning effectively.

A learner-centred approach is also supported by Lotz-Sisitka, Olvitt, Gumede, and Pesanayi (2006) who reported on (ESD) practices and noted that learner-centred, active approaches to learning are strongly supported in Southern African environmental education/ESD. The teacher should be able to facilitate learning by stimulating learners to ask questions, think critically and offer creative solutions (Fundisa for Change, 2013, p. 13). Therefore, the successful teaching in environmental learning will depend on teachers' chosen methods. CAPS is silent on this, as it does not prescribe particular instructional strategies or methods (South Africa. DBE, 2011a, p. 10).

Hogan (2008) highlighted the use of everyday contexts and experience for meaningful learning. She argued that using everyday contexts involves learners in classroom activities that increase learners' confidence in solving local issues. She found that integrating local environmental issues successfully contributes to curriculum relevance. UNEP (2006) supported this by noting that the study of issues and concerns related to the environment should engage learners and should be relevant to their communities.

Ketlhoilwe (2003) declared that, for a conducive learning environment to be created, there should be more opportunities for fieldwork and projects to supplement theoretical classroom activities. Similar to Chi-chung Ko and Hci-kin Lee's (2003) study in Hong Kong,

Ketlhoilwe (2003) indicated that fieldwork is seldom done due to transport and time constraints.

2.7 Assessment and curriculum competencies in CAPS

Assessment is a continuous planned process of identifying, gathering and interpreting information on learners' performance, using various forms of assessment (South Africa. DBE, 2011a). According to the CAPS curriculum, assessment in Life Sciences must cater for a range of cognitive skills (competencies[1]) that have been outlined for each of the specific aims (South Africa. DBE, 2011a). This study focuses on how teachers use assessment strategies to develop curriculum and sustainability competencies. CAPS explicitly outlines the forms of assessment that must be used, but teachers are encouraged also to give informal assessment as it provides feedback to learners about their performance and informs the planning for teaching and informs the development of assessment. Table 2.1 below shows the forms of formal assessment required by CAPS for Life Sciences Grade 11 for each term as well as the percentages each should contribute to the total mark.

Table 2.1: Formal school-based assessment for Grade 11

Term 1	Term 2	Term 3	Term 4	final Examination
One test	One test	One test	One test	
One selected practical task	One selected practical task	One selected practical task	One project/ assignment	
	Mid- year examination	Environmental Studies: fieldwork		
25%	25%	25%	25%	75%

The above table is important to this research as it shows the different forms of assessment within which curriculum competencies can be developed. The CAPS curriculum is content-based but highlights that content knowledge needs to be developed in tandem with these competencies. These curriculum competencies emphasise low, medium and higher order cognitive demand (see Table 2.2) below.

[1] The Life Sciences CAPS curriculum equates cognitive skills with competencies.

Table 2.2: Weighting of cognitive demand (competencies) for the assessment of content in Life Sciences Grades 10, 11 and 12 (South Africa. DBE, 2011a, p. 67; South Africa. DBE, 2011a, p. 87)

	Knowing Science	Understanding Science	Applying Science	Evaluating, analysing and synthesising scientific knowledge
	Low Order	Medium Order		High Order
%	40%	25%	20%	15%
Examples of useful verbs	State Name Label List Define Describe and others	Explain Compare Rearrange Give example of Illustrate Calculate Make a generalisation and others	Predict Apply Use knowledge Demonstrate Solve Implement Judge and others	Select Differentiate Analyse Infer Suggest a reason Discuss Categorise and others

This table is used in the thesis to explore cognitive levels development and weighting in the methods and assessment practices reviewed. It has been one of the suggestions of the 2013 examiners' report that learners should understand what is required by the different action verbs mentioned in the table above used in examination questions (National Diagnostic Report, 2013, p. 121).

The table below lists the curriculum competencies Life Sciences teachers are expected to develop in learners in relation to each of the specific aims. The table outlines the three specific aims and the skills each aim relates to curriculum competencies. The table below is summarised from the Life Sciences CAPS document (South Africa. DBE, 2011a)

Table 2.3: Outline of specific aims and curriculum competencies learners are expected to acquire during teaching and learning

Specific Aims	CURRICULUM DEFINED COMPETENCIES (CAPS)
Specific Aim 1 Content knowledge	**Acquire knowledge**: access information, describe concepts and processes, recall facts, select key ideas, build a conceptual framework of science ideas, organise or reorganise knowledge to derive new meaning, write summaries, develop flow charts, diagrams and mind maps, recognise patterns and trends. **Apply knowledge on Life Sciences in new and unfamiliar contexts:** use information in a new way and apply knowledge to new and unfamiliar contexts. **Analyze, evaluate and synthesise scientific knowledge, concepts and ideas**: Analyse information/ data, recognise relationships between existing knowledge and new ideas, critically evaluate scientific information, identify assumptions and categorise information.
Specific Aim 2 Investigating phenomena	Follow instructions, make observations, handle equipment or apparatus, record data or information, measure, interpret, design/ plan investigations or experiments
Specific Aim 3 Appreciating and understanding the history, importance and applications of Life Sciences in Society	Understanding the history and relevance of some scientific discoveries, the relationship between indigenous knowledge and Life Sciences and the value and application of Life Sciences Knowledge in the industry in respect of career opportunities and everyday life.

According to curriculum policy, the specific aims, topics, content and range of cognitive skills in the subject should be used to inform the planning and development of assessments (South Africa. DBE, 2011a, p. 67). In this study teaching methods and assessment tasks designed and implemented by teachers will be analysed according to the curriculum competencies mentioned above. However, in order to avoid a reductionist view on these competencies, they will be related to an integrated and systems approach to sustainability competencies as elaborated in Section 2.9 below.

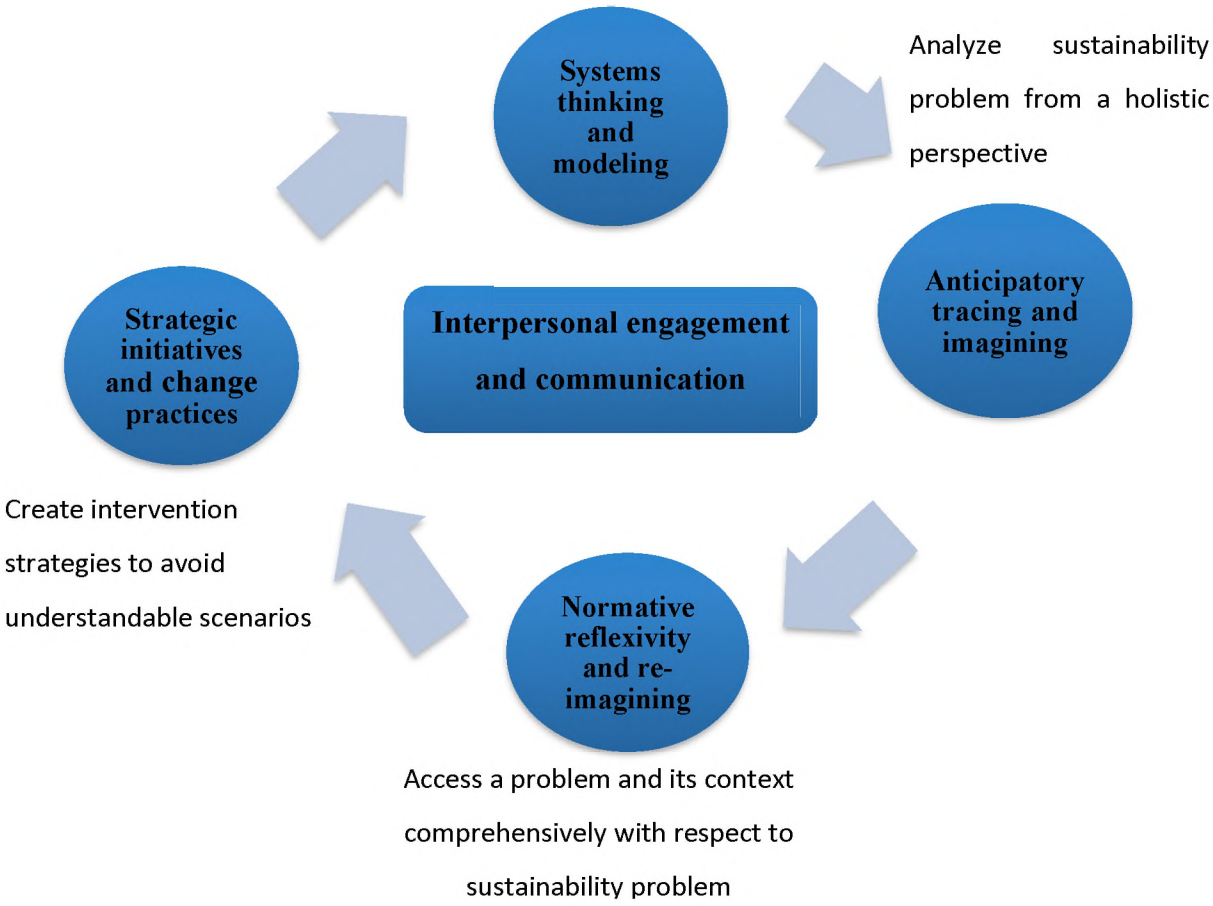
2.8 A systems approach to sustainability competency

Part of the aim of this study is to investigate the relationship between CAPS Life Sciences competencies and sustainability competencies in the context of environmental learning.

Wiek et al. (2011) emphasised that competencies considered essential for sustainability have not been the focus of traditional education and therefore require special attention. They argued that sustainability education should enable learners to analyse and solve sustainability problems, to anticipate and prepare for future sustainability challenges, as well as to create and seize opportunities for sustainability. Because sustainability problems and challenges have specific characteristics, analysing and solving sustainability problems requires the particular set of interlinked and interdependent key competencies proposed by Wiek et al. (2011).

A systems approach to competency will be used as a lens for examining the development of Life Sciences curriculum and sustainability competencies. Life Sciences teaching and assessment practices will be examined with respect to how they relate to the five competencies for transformative processes as outlined by Wiek et al. (2011). Figure 2.1 presents O'Donoghue's (2011) adaptation of Wiek et al.'s model representing a series of five interrelated competencies as key dimensions of sustainability competency.

Figure 2.1: Competencies for transformative learning process (O'Donoghue, 2011 adapted from Wiek et al., 2011)



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). This would include describing how human activities contribute to, solve or mitigate sustainability problems (Wiek et al., 2011).
2) Anticipatory tracing and imagining (futures thinking) is the ability to employ future thinking in sustainability problem solving. For example, anticipating how a sustainability problem might evolve over time. It is also a pursuit of visions and the ability to make decisions to prevent and mitigate sustainability problems (Wiek et al., 2011).
3) Strategic initiatives and change practices (action-oriented competence) involve the ability to develop and test systemic interventions, transformational actions and transition strategies in relation to sustainability problems. For example, they involve the activities that can make a sustainable vision happen. Activities include strategic

plans of how to mitigate sustainability problems (Wiek et al., 2011). Wiek highlighted that "a solution always has two parts: a vision (what do we want to accomplish?) and a strategy (how do we get there?). Strategic competence is only about the second part" (A. Wiek, personal communication, July 18, 2015).

4) Interpersonal engagement and communication or collaboration is the ability to initiate, facilitate and support different types of collaboration, including articulating the roles, responsibilities and contributions of 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 how to effectively work with different stakeholders (Wiek et al., 2011).
5) Normative reflexivity and re-imagining or values thinking 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). "Normative competence is really about values and enables students to differentiate and pursue sustainability values" (A. Wiek, personal communication, July 18, 2015).

According to Wiek et al. (2011) these competencies can be applied to undergraduate and/or graduate programmes, and even in efforts to prepare high school students for sustainability programmes in higher education institutions. For this study, the above five competencies central to a systems approach to learning will be used as a lens for reviewing the development of Life Sciences curriculum competencies in the context of environmental learning. This lens will help with a review of learners' competence for working on solutions to real-world sustainability challenges. In the following chapters of this thesis, these five competencies will be referred to as 'sustainability competencies'.

2.9 A competency critique

This section highlights some key axes of tension regarding the notion of competencies as they are interpreted and enacted in different ways and with different intentions in different contexts. The section draws predominantly on an international perspective on the notion of competencies offered by Barnett (1994) and a South African perspective on competencies offered by Christie (1997). These perspectives highlight the following concerns about the notion of competence and its application in educational contexts:

- Responsiveness and transferability of competencies in different contexts,

- Competencies promoting an instrumentalist purpose in education and lacks reflexivity,
- Fragmentation of knowledge through the competence approach.

These potential problems with using competencies in educational contexts are integrated into the discussion below which outlines the particular approach to competencies taken in this study.

Barnett (1994) described two approaches to competence; namely an academic approach which focuses on student mastery within a discipline as well as an operational approach to the competence concept that defines competence as skills, outcomes, transferability, and enterprise and credit accumulation. According to Barnett (1994), operational competencies refer to a broad range of higher order skills and behaviours that represent the ability to cope with complex, unpredictable situations. Coping with such new situations in a creative way is assumed to be a critical part of the concept of this notion of competence.

Barnett raises concerns about each of these approaches and proposes a third way forward that goes beyond competencies. However, for this study, the decision was to still use the notion of competencies as a conceptual framework because competency was a key driver in the development of the outcomes-based system (Christie, 1997) which dominated South African curriculum for 18 years. The outcomes-based system could be argued to fit with the elements of an operational competence system which, according to Barnett (1994), include a focus on 'know how' (rather than 'know that'), outcomes, experiential learning, economic survival and better practical effectiveness. Also, the current Life Sciences CAPS curriculum still highlights the importance of competencies in its reference to cognitive skills (see Section 2.7 which explains how the CAPS curriculum equates cognitive skills with competence). This content-based CAPS system could be argued to fit Barnett's (1994) conception of academic competencies which emphasise 'know that', relative strength of discipline, and better cognitive understanding.

One of Barnett's (1994) concerns was the need for the development of responsiveness, because coping with profound societal, international and ecological change cannot be simply covered by the concept of standardised competencies. In his view, no standardised competencies can be identified that carry us forward in a changing world because while competencies may be stable, they become worthless in a changing world. The problem of a

changing world is also highlighted in the South African Fundisa for Change programme which warns that: sustainability knowledge 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, 2013, p. 7).

In response to the concern regarding standardised competencies, this study focusses on a perspective on competence developed by Haan and Seitz (2001) who defined competence as having knowledge and skills to enact changes in economic, ecological and social behaviour without such changes being merely a reaction to pre-existing problems. This means that there is a need for a responsive rather than a standardised approach to education. In an operational approach to competencies, Wiek et al. (2011) defined 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" (Wiek et al., 2011, p. 204). The sets of five competencies could be argued to be broad enough to not be limiting in their standardisation. Applicability in a variety of contexts could be argued to be an indicator that the notion of competencies is not seen in a limiting and standardising way, but in an expansive and responsive way.

De Haan (2006) and Wiek et al.'s (2011) definition of competence specifically involves a number of key competencies which accommodate the topical knowledge required for successful problem solving in a particular context. For this study, the assumption is that the problem-solving framework that underpins Wiek et al.'s conception of competencies is a framework that will enable responsiveness to constantly changing real-world problems and enable the application of acquired competencies in different contexts. Such a view of competencies as transferable is consistent with the view of competencies developed in South Africa at the time of the development of the outcomes-based approach to education. This view of competencies was influenced by an Australian report which 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, p. 56).

According to Barnett (1994), operational competence proclaims to represent a higher level of competence by introducing the idea of coping with unpredictability. He acknowledged that "we live in an unpredictable age, and corporate life is one of living effectively with continuous change" (Barnett, 1994, p. 173). Similarly, the CAPS curriculum implies a need

for coping with unpredictability and open-endedness as necessitated in the curriculum principle focusing on the complex relationship between a healthy environment, human rights, social justice and inclusivity (South Africa. DBE, 2011a). It is this principle statement that ensures an environmental focus in all school subjects (Fundisa for Change, 2013) and which is evident in, for example, the Life Sciences content knowledge which requires learners to "engage actively with complex social and ecological concepts, issues and risks relating to local and global contexts" (Fundisa for Change, 2013. p.11).

From an environmental learning perspective, open-endedness is a significant concern as environmental learning needs to deal with the complex social-ecological nature of environment issues which requires people to deal with "uncertainty, poorly-defined situations conflicting, or at least diverging, norms, values, interests, and reality constructions" (Wals & Jickling, 2009, p. 78). From an operational perspective Wiek et al.'s (2011) sustainability competencies seem to cover the broad range of higher order skills and behaviours that represent the ability to cope with complex, unpredictable situations. South Africa's Fundisa programme aims to develop learners' capacity for understanding "social and ecological change processes, and therefore … to actively conceptualise and prepare themselves for action, or actually engage in action-oriented learning processes" (Fundisa for Change, 2013, p. 11).

However, according to Barnett (1994), the notion of operational competence and its claims on dealing with unpredictability, views people 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. This is the second concern with competencies raised in this study.

In South Africa, the notion of outcomes-based education has been similarly critiqued by authors such as McKernan (1994 cited in Jansen, 1998) who pointed out the instrumentalism of a "means-ends" stance in education or a linear approach to education. McKernan (1994 cited in Jansen, 1998, p. 2) presented "the mechanical repair of a bicycle tube" as an example of such an instrumentalist approach to working with outcomes.

Spady (1994) argued that this linearity of pre-determined outcomes discourages reflexivity. However, in the South African schooling context it does not appear that this is necessarily the curriculum intention considering that a call for reflexivity was evident as a critical outcome in

both C2005 and in the RNCS. This same outcome has now been re-stated as one of the aims of the current CAPS curriculum which states that learners must be able to "use science and technology effectively and critically showing responsibility towards the environment and health of others" (South Africa. DBE, 2011a, p. 5). So, despite the critique offered above highlighting instrumentalist approaches to outcomes, these aims/critical outcomes illustrate that in the schooling system in South Africa there was, and is, an underpinning ideology that called for critical, creative and reflexive thinking.

The sustainability competencies model on which this study relies, do not have the same problem of instrumentalist outcomes nor linearity nor 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, necessarily need open-ended responses and therefore particular pre-determined outcomes or competencies cannot be dictated. Additionally, Wiek et al.'s (ibid.) approach to sustainability competencies and strategic thinking requires that learners look back critically (reflexively) at their own ideas and practice and change them as a result of this reflection (Fundisa for Change, 2013, p. 14).

Another concern with the notion of competencies is the argument that curriculum competencies ought not to be seen in a reductionist sense (MacFarlane & Lomas, 1994). The problem of reductionism (or atomisation or fragmentation of competencies) is also a problem that has been highlighted in critiques of outcomes-based and competency-based education. For example, Holland (1994 in Jansen, 1999, p. 152) in a review of outcomes-based education at the time of South Africa's post-Apartheid curriculum revision, raised the concern that outcomes-base education "overlooks the important cross-curricular and interdisciplinary demands encountered in learning a complex task".

In South Africa, the problem of reductionism was clearly taken into account in C2005 where "integration and deriving common themes across a phase was privileged in planning" (Dada et al., 2009, p. 26). Yet ironically, integration became a problem as its emphasis continued in the RNCS. Dada et al. (ibid., p. 24) explained that the root of the problem was in "integration realised through theme-driven learning [which] compromised conceptual learning and progression within subjects". Then the CAPS curriculum's emphasis on addressing the issue of fragmentation of content through the notion of progression in its principle that calls for the

"content and context of each grade [to show] progression from simple to complex". This is an instance of a focus on 'vertical integration' within a subject rather than the horizontal integration across subjects that was the focus of C2005 and the RNCS (Dada et al., 2009).

For this study, it is assumed that the five competencies as suggested by Wiek et al. (2011) above also specifically guard against reductionism as they are seen as a functionally linked complex of knowledge, skills and attitudes. This point is highlighted when the authors describe competencies as "conceptually embedded sets of interlinked competencies" (Wiek et al., 2011, introduction, paragraph 7) that enable successful task performance and problem solving with respect to real-world sustainability problems, challenges and opportunities. Koning et al. (2005, in Wiek et al., 2009) stated that competencies are interrelated as one systematically leads to another. This highlights a different way of looking at integration as opposed to vertical and horizontal as described above. This integration of competencies can be said to be an integration of skills and knowledge around a particular problem. De Kraker, Lansu and van Dam-Mieras (2007, p. 109) also highlighted the importance of integration when working with the notion of competencies when they noted that "learning should focus on integrative competences required in professional life, and not on the acquisition of isolated skills and pieces of knowledge". They emphasised that this is a different perspective on competencies beyond a list of competencies (ibid.). A competency defined in this way accommodates the topical knowledge required for successful problem solving in a particular context.

The above discussion highlights problems with a competency-based approach to learning including lack of responsiveness reflexivity, and fragmentation. However, what becomes evident as the pros and cons of competency frameworks in education are discussed is that often the problem is either in a narrow interpretation or in a difficulty with implementation rather than a problem inherent in competence itself. These potential problems have been discussed in the light of curriculum intentions and intentions of environmental learning, acknowledging that the competency discourse is still critical from both a formal schooling curriculum as well as an environmental learning perspective. These 'warning signs' enable a critical perspective on environmental learning in the school context and are borne in mind in the discussion of the data in this study.

2.10 Conclusion

To fully understand the broad overview of the context within which the research has been set, this chapter has outlined the historicity of environmental education across national curriculum changes and challenges in South Africa. The chapter emphasised teaching and assessment practices specifically relating to environmental learning processes of the Life Sciences curriculum. It also explored competency in a sustainability context, by elaborating on the five key sustainability competencies described by Wiek et al. (2011). The study also finally considered the concerns made by other authors around the notion of competence in education. The chapter that follows discusses the methodology that was employed in the research.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research process and activities that were used to investigate the research question of how teachers implement teaching and assessment practices in developing Life Sciences curricula and sustainability competencies. It starts by explaining the research orientation in relation to the purpose of the research and then describes and justifies the use of case studies for this research. It also describes the choice of participants for the study and the process of generating data (questionnaire, document research, lesson observation and semi-structured interviews) and relates each of these to the research question and goals. Additionally, the chapter explains how data were analysed and discusses issues of validity and reliability, ethics and limitations of the study.

3.2.1 Research orientation

This study is influenced by an interpretive paradigm, because knowledge is constructed not only by observable phenomena but also by descriptions of people's meaning-making and self-understanding (Henning, 2004). According to Neuman (1997), an interpretive approach is defined as the systematic analysis of socially meaningful action through direct settings in order to arrive at understandings and interpretations of how people create and maintain their social worlds. In this case, the socially meaningful action was teachers' teaching and assessment of curriculum competencies when working with environmental content in the Life Sciences curriculum.

Interpretive orientations allow for an opportunity to understand the situation of the phenomena being studied by learning through the process of interaction (Cohen & Manion, 1994, p. 37). This is appropriate for this study where the aim was to understand the teachers' experiences by interacting with them and listening to what they said. The study was designed to provide rich insights and understanding of the teachers' practices regarding the mediation and assessment of environmental content knowledge in Life Sciences in relation to the development of the CAPS curriculum and sustainability competencies.

3.2.2 Case study approach

A case study approach enables the collection of information that is specific to the particular case (Stake, 1995). It is useful in seeking to understand complex social phenomena, while

allowing an investigation to retain the holistic and meaningful characteristics of real-life events. I chose the case study approach because case studies are used to observe effects in real contexts (Cohen et al., 2007), and in this instance the real context was the schools.

The study is based on four case studies of four Grade 11 Life Sciences teachers who were selected to provide rich insights and understanding of the CAPS Life Sciences environmental content knowledge. The case study enables the collection of information that is specific to the particular case and the idea of each case is to understand that particular case under study (Stake, 1995). Patton (1990) observes that case studies become particularly useful where one needs to understand a particular person's or group of people's problem, in great depth.

This case study approach helped me to get close enough to the participants (teachers and learners) and the context (schools) to personally understand in depth the details of what was happening and to capture what actually took place. The findings of this study will not be used to generalise how Life Sciences teachers mediate environmental content knowledge. However, it may be useful for deepening insights into potential challenges and opportunities for teaching and assessment amongst teachers as well as educators wanting to improve the quality of environmental education in the Life Sciences in schools.

3.3 Participants and site

The study was conducted in a rural town in the KwaZulu-Natal Midlands area, South Africa There are five schools in this town's circuit that offer Life Sciences in Grades 10-12. Four of these schools, with one participant from each school, participated in the study. Participating schools were selected according to their performances in Life Sciences: two from well-performing schools and two from underperforming schools. Three of these schools were farm schools and the fourth was an ex-model C school. Therefore, this was purposive sampling which means that "participants are selected because of some defining characteristics that make them holders of the data needed for the study" (Marre, 2007, p. 79). In this study, the defining characteristic was the learners' performance in Life Sciences. This type of sampling made it possible to build up a sample that was specific to the study (Cohen et al., 2007).

3.4 Data generation process

The methods used to generate data included questionnaires, document analysis, lesson observations and semi-structured interviews. Each of these is discussed in detail below.

3.4.1 Questionnaire

A structured questionnaire (see Appendix 1) was used at each school – one per teacher. This was an open-ended questionnaire which invited personal comments from teachers. Patton (2002) explained that written responses to questionnaires take the form of documents that require examination. Questionnaires can have both open-ended and closed questions with predetermined response categories. The questionnaire sought information about the school and teacher context, the availability of teaching resources, teacher learner ratio, infrastructure (electricity, classrooms), human resources, the school quintile, social factors, teaching experience, methods and assessment. All four teachers completed the questionnaire which was collected and analysed towards achieving Goal 1 of the research: To investigate the contextual factors influencing classroom teaching and assessment practices.

3.4.2 Lesson observations

After administration of the questionnaires, lesson observations were conducted to seek insight into the challenges and realities of the classroom situation. Stake (1995) indicated that using observations helps to increase understanding of the case being studied. Croll (1986) stated that an observation is an attempt to describe first-hand direct experience and thus enables the generation of detailed descriptions of the setting, the activities, interactions and participants' experiences. Morrison (as cited in Cohen et al., 2007, p. 397) stated that observations enable the researcher to gather data on:

- the physical setting (e.g. the physical environment and its organisation);
- the human setting (e.g. the organisation of the people, and the characteristics and make-up of the groups or individuals being observed, for instance, gender, class);
- the interactional setting (e.g. the interactions that are taking place, formal, informal, planned, unplanned, verbal etc.); and
- the programme setting (e.g. the resources and their organisation, pedagogic styles, curricula and their organisation).

According to Cohen et al. (2007, p. 396), the distinctive feature of observation as a research process is that it "offers an investigator the opportunity to gather 'live' data from naturally occurring social settings". They further stated that "the researcher can look directly at what is taking place *in situ* rather than relying on second-hand accounts" (p. 396).

The weakness of observation as a method, highlighted by Simpson and Tuson (2003), is that observation is susceptible to various factors. One of these is bias, which might occur either

because the observer records what he or she thought occurred rather than what actually took place, or because of the observer's lack of attention to significant events. To address this weakness, lessons were videoed and photographs were taken in order to give the researcher and the Life Sciences teacher a chance to view a lesson afterwards to clarify matters that arose during the lesson presentation. Photographs referred to in the study are presented as a series of 'plates' in Chapter 4 of this thesis.

Seven lessons were observed from four schools. The plan was to observe eight lessons in total, two from each of four schools; but due to challenges with one school, the second lesson was not observed. Of the seven lessons observed, two were not analysed as, despite my request to teachers to observe lessons with an environmental focus, the lessons to which I was invited did not focus on human-environment relationships (the essence of environmental learning). These lessons thus fell outside of the scope of this study. The five remaining lessons were transcribed for analysis (see Appendix 2 for an example of one of these transcripts).

One of the lessons observed needed to be translated from isiZulu into English. Polkinghorne (2005) cautions that meaning may be distorted when gathered data are translated from one language to another. As an isiZulu speaker, I was able to do the translation myself to English.

The lesson observations enabled the generation of detailed descriptions of the classroom setting, teaching methods used, the lesson activities, types of assessment, teaching and learning materials used to present environmental content knowledge, and teacher interactions with the learners. The duration for the lessons were an hour each. As a non-participant observer, I took a seat at the back of the classroom and did not say anything during the lessons.

3.4.3 Stimulated recall interviews

After the lesson observations, video-stimulated interviews were conducted based on the lessons presented. Interviews were structured in order to generate data to address Goal 1: To investigate the local contextual factors influencing classroom teaching and assessment practices; Goal 2: To investigate curriculum planning, teaching and assessment practices; and Goal 3: To investigate the development and emergence of curriculum competency in informal and formal assessment in environmental learning. The aim was to provide an opportunity to maintain a real-life context. This type of interview was used because it favoured a 'stop and

remember' rather than a 'talk you through it' approach. This provided an opportunity for both researcher and the teacher to reflect on the lesson presented. Yinger (1986) noted that the result of this opportunity for reflection in stimulated recall interviews is that the subjects report what they are currently thinking and take the opportunity to elaborate the reasons for their interpretation of the video recording. According to Cohen et al. (2007), an interview is a flexible tool for generating data. Kvale (1996, cited in Cohen et al., 2007) viewed an interview as a tool that recognises people as resources of knowledge generation through exchange of ideas on topics of mutual interest and conversation.

Stimulated recall interviews were conducted to create opportunities for teachers to provide in-depth information. Three educators were interviewed; each had one interview except for one teacher who had two interviews.

There were four interviews in total and these were tape recorded. During the interview, I played the videoed lesson and watched it together with the teacher of that lesson. The video was paused intermittently to allow discussion. The questions were focused on lesson intentionality, teaching methods, as well as curriculum competencies that emerged in response to certain mediation and assessment strategies implemented by the teacher.

Interviews were audio recorded and transcribed. Three teachers were second language English speakers (two teachers' first language being isiZulu, the other, Shona) and for data authenticity, grammar or English used in the lesson transcription and presentation of quotes in the thesis was not corrected (see Appendix 3 as an example of a transcribed interview).

3.4.4 Documentary evidence

Documents are primary sources that are useful in qualitative research because of the nature of the data they contain (Yin, 2011). According to Cohen and Manion (2004), primary sources are original objects that are related directly to the events being investigated. This method was used to read and analyse documents giving insights into teachers' teaching methods and assessment practices. The documents that were analysed were:

- Five lesson plans, which provided teachers' implicit and explicit intentionality in relation to curriculum and sustainability competencies, teaching methods used, as well as the teaching interactions (see Appendices 4.1 to 4.5).

- Seven assessment tasks (four informal and three formal), which provided evidence of the development of curriculum and sustainability competencies. These assessment tasks provided the evidence of assessment practices used and the types of questions used (see Appendices 5.1, 5.3, 5.5, 5.7 and 5.9).
- Six samples of learners' work, per task which provided evidence of learners' development of curriculum and sustainability competencies (see Appendices 5.2, 5.4, 5.6, 5.8, 5.10, 5.12 and 5.14 as examples).

3.4.5 Additional questionnaire

One informal interview was replaced by a questionnaire after several attempts were made to contact the teacher through the use of a telephone. His school is an Agricultural College. Every year towards the end of third term, they offer farming courses to Grade 11 learners. He was so busy that he did not have time for the interview. The questions were hand delivered to his school and collected once completed. This questionnaire is included in Appendix 6.

3.4.6 Summary of data generation methods

Table 3.1 below summarises the data generation methods discussed above together with their reference labels as used in Chapter 4.

Table 3.1: Summary of data generation methods

Method	With whom	Reference label	Appendix
Questionnaires (contextual profile)	4 teacher profiles in total, 1 from each teacher	[School initials] TP 1- 4	Appendix 1
Lesson observations	5 lesson observations in total, 1 each from 3 teachers and 2 from 1 teacher	[school initials] observ.1-2	Appendix 2
Stimulated recall interview transcript	4 interviews in total, 1 interview with 2 teachers and 2 with 1 teacher	[school initials] interv. 1-2	Appendix 3
Documents analysed (a) Lesson plans	5 lesson plans, 1 each for 3 teachers and two for 1 teacher	[school initials] LP1-5	Appendix 4
(b) Assessment tasks	7 assessment tasks, 1 each from 2 teachers, 2 from 1 teacher and 3 from the other teacher	[school initials] AT1-2	Appendices 5.1, 5.3, 5.5, 5.7, 5.9, 5.11. 5.13
(c) Learners' work	6 learners' work per assessment task. 30 samples in total	[school initials] LW1-2	Appendices 5.2, 5.4, 5.6, 5.8, 5.10, 5.12, 5.14
Additional questionnaire	1 interview replaced by an additional questionnaire from 1 teacher	TONIC1	Appendix 6

All the data generation methods described above were included in the data analysis as described below.

3.5 Data analysis

According to Gay, Mills and Airasian (2006), data analysis is the process of making sense and finding meaning in the data, interpreting what has been seen and what has been said. Qualitative analysis is a relatively systematic process of coding, categorising and interpreting data to provide explanations of a single phenomenon of interest. According to Stake (1995), data analysis is the process the researcher engages in, in order to make visible information that is hidden in data, and to convert it to beneficial and meaningful information. Data analysis is a process of working with data to demonstrate the meaning of written or visual sources by systematically allocating their content to pre-determined, detailed categories and interpreting their outcomes (Payne & Payne, 2004).

Data analysis in this study took place in four phases in response to the four goals of the study as outlined in Section 1.2.

- Phase 1 responded to Goal 1 of the study which was to: Investigate the contextual factors that influence classroom teaching and assessment practices.
- Phase 2 responded to Goal 2 of the study which was to: Investigate curriculum planning, teaching and assessment practices.
- Phase 3 responded to Goal 3 of the study which was to: Investigate the development and emergence of curriculum competency in informal and formal assessment in environmental learning.
- Phase 4 responded to Goal 4 of the study which was to: Investigate the emergence of an integrated approach to developing sustainability competencies in environmental learning processes.

Data was organised into four different analytical memos as part of the analytic process:

- Analytic Memo 1: Contextual analysis;
- Analytical Memo 2.1: Curriculum planning and assessment practices,
- Analytical Memo 2.2: Teaching methods and lesson activities;
- Analytical Memo 3: Cognitive skills and cognitive levels in Informal and formal assessment tasks; and
- Analytical Memo 4: Emergence of five sustainability competencies.

3.5.1 Phase 1 data analysis: Contextual profiling

The Phase 1 data analysis in this study entailed analysis of the contextual profiling questionnaires (see Analytical memo 1 – Appendix 8.1). This analysis was descriptive in its presentation of the social-ecological context of the school, community, teacher educational positions and practices. The intention was to establish contextual factors that influence the classroom teaching and assessment practices (Goal 1). Data generated through contextual profiles was analysed by categorizing issues. The following contextual aspects were captured in the memo: Demographic, social factors, structural factors and teacher qualifications.

3.5.2 Phase 2 data analysis: Curriculum planning, teaching and assessment

In this phase, lessons and stimulated interviews were summarised and categorised according to curriculum and teacher intentionality, topics, assessment planned and resources used (Analytical memo 2.1 - Appendix 8.2. Analytic Memo 2.1 was addressing part of Goal 2. Additionally, the data generated through lesson observations and stimulated recall interviews were transcribed, coded and categorised according to teaching methods and assessment practices used during teaching and learning (Analytical memo 2.2 - Appendix 8.3). Analytic

Memo 2.2 further addressed Goal 2. Direct quotations from teachers were transferred into the memos to enable their ideas to emerge in this study.

3.5.3 Phase 3 data analysis: Curriculum competencies

In this phase assessment tasks and learners' work were analysed to explore the emergence of curriculum competencies in informal and formal tasks.

Completed assessment tasks from all five observed lessons were analysed and categorised for evidence of the emergence of cognitive skills and cognitive levels (low, medium and high order questions as discussed (see Table 2.2) as well as learner performance at each level. This analysis is presented in table form for each teacher in Chapter 4 to address Goal 3
There were four informal assessment tasks and three formal assessment tasks.

One of the three formal tasks was analysed differently as it did not have a rubric showing how marks were allocated. Analysis of assessment tasks thus took place in four groups as described below.

1) For two of the three formal tasks, learners were given marks by the teacher and these were recorded for their year mark. Analysis of these tasks was done in two parts. Part 1 was an analysis of the actual task set by the teacher according to the cognitive skills for the different specific aims as outlined in the CAPS curriculum, as well as the cognitive level of each of these skills. The cognitive level was determined by the distinction between low, medium and high order cognitive levels as outlined in the Senior Phase Natural Science CAPS document (South Africa. DBE. 2011b. p. 87). Part 2 was an analysis of the six examples of learners' work associated with each of these tasks. These examples were chosen according to learner performance in terms of marks attained in the tasks given. The first two examples were those graded at the highest level, the second two examples were graded at a medium level and the last two were the learners' work graded at the lowest level. Each example of learners' work was analysed according to the marks given by the teacher for the separate parts or specific questions. To help categorise learners' achievements, the marks for each section were converted into a percentage. Percentages given were analysed according to seven levels of achievement ranging from 1 to 7 as prescribed in the National Protocol for Assessment (South Africa. DBE. 2011c, p. 14). In this study percentages from 60% to 100% were categorised in the range of level 5 to 7. Percentages from

30% to 59% were categorised in the range of level 2 to 4. Percentages from 0 to 29% were categorised as level 1.

2) In the third formal task, an analysis was done according to the cognitive levels and cognitive skills that emerged in the learners' responses.
3) In two of the four informal tasks, learners were given marks by the teacher and these were used informatively (not counted for year marks). These were analysed in the same way as the formal tasks as described above.
4) For the other two informal tasks, learners were not given marks but verbal feedback on oral presentations. These tasks were analysed in two parts. The first part (the actual task) was analysed in the same way as the formal tasks as described above. Because these tasks were not allocated marks, the Part 2 analysis was simply descriptive of the learners' responses

3.5.4 Phase 4 data analysis: Sustainability competencies

This analysis phase was aimed towards achieving Goal 4 by investigating the representation of sustainability competencies across the learning activities. The key features for each of Wiek et al.'s sustainability competencies were drawn on from Chapter 2 (see Section 2.11). The analysis examined the particular teaching and assessment practices used by the teachers and explored to what extent the environmental learning reflected an integrated approach to sustainability competencies as outlined by Wiek et al. (2011). The analysis at this phase was a second level analysis of analytical memos 2.1, 2.2 and 3 and was captured in Analytical Memo 4 (Appendix 8.5).

The analysis focused on the development of skills relevant to sustainability competencies, such as ability to analyse given situations and phenomena (which was linked to systems thinking and modeling); to critically evaluate the future impact of such a phenomenon or situation (which was linked to anticipatory tracing and imagining); to recognise contextual factors that exist and lead to such a situation or phenomena (for example, human behaviour and its impact on the environment linked to systems thinking) and critically think how to overcome them (normative reflexivity and re-imagining). Further analysis of interpersonal communication and the use and application of knowledge in a new context, examined how learners used knowledge gained to address local or global situations/environmental problems, and avoid future occurrences of such situations (strategic initiatives and changes practices).

3.6 Validity and trustworthiness

A variety of methods was used to generate data in order to strengthen the validity of the findings. Methodological triangulation (Cohen et al., 2007) was used to reduce the weaknesses and partiality of using only one method of data generation. To ensure validity and trustworthiness in the study, four methods of data collection were used: questionnaires, lesson observations, stimulated recall interviews and document analysis. Patton (2002) advocates the use of triangulation by stating that triangulation strengthens a study by combining methods. The questionnaire was used to generate data on contextual analysis and teacher profile. Lesson observations, stimulated recall interviews and CAPS document analysis as well as lesson plans were used to generate data on curriculum planning, teaching methods and assessment practices. Assessment tasks and learners' work were used to analyse the emergence and development of curriculum and sustainability competencies.

For reflecting on validity and trustworthiness in this study, I also considered interpretive validity and descriptive validity. According to Maxwell (1992, p. 288), interpretive validity can be described as "appropriate primarily because this aspect of understanding is most central to interpretive research, which seeks to comprehend phenomena as the interpretation of interviews relied as much as possible on the participants' own words and concepts (interpretive data). The information which I reported in Chapter 4 was as true to the intended meanings of the teachers as possible to ensure that I understood the teachers' perspectives on the lessons they were conducting. A video recorder and field notes were used to capture the data and reflect on what had been interpreted. The videoed lessons were analysed with the participants using stimulated recall interviews in order to strengthen the validity of the claims made. This provided the opportunity to share my interpretations with teachers in order to validate these interpretations. A thick description, necessary for accurate explanation and interpretation of events, has been provided (see Chapter 4) to add to the trustworthiness of the study.

It was never my intention to 'prove' a particular perspective or manipulate the data to arrive at predisposed truths (Patton, 1990). What I did was try to understand the world as it is, to be true to complexities and multiple perspectives as they emerged. To represent the original data, I used direct quotations from teachers as a way of providing depth.

3.7 Ethics

I visited the schools personally first to speak to the principals and the Grade 11 Life Sciences teachers to ask for permission to work with them in the study. Informed consent forms were issued to participating schools (see Appendix 7a). The informed consent forms had the following information (guided by Leedy and Omrod, 2005): a brief description of the purpose of the study, statement of voluntary participation, guarantee that all responses would remain confidential and anonymous, place for participants to sign and date the letter indicating agreement to participate, researcher's name and supervisor's name and how they could be contacted. The request to conduct research was further sought from the Department of Basic Education (KwaZulu-Natal Head Office) (see Appendix 7b). According to Diener (1978, cited in Cohen et al., 2007), informed consent is the procedure by which individuals choose whether to participate in an investigation after being informed of the facts that are likely to influence their decisions. Anonymity was ensured by giving codes for school names as well as by hiding faces of participants and blocking the school name on assessment tasks.

Drawing on Bassey (1999), I discussed with participants their option to withdraw from the study at any time if they so desired.

I was the ward leader for the Life Sciences cluster from which the participants were drawn, but my role did not make participants feel pressured to participate in the study. In our cluster, we work as a team and contribute to each other's development as we discuss our common teaching and learning challenges. I ensured that my colleagues benefitted from experiences I was exposed to, for example, I shared the knowledge of teaching methods and resources I received from Fundisa for Change workshops.

3.8 Limitations of this study

As explained in Section 3.4.3 above, seven lessons were observed, but two were lessons which were not related to human interaction with the environment. This meant they could not be used as data because sustainability competences are only applicable when considering problem-solving in the context of socio-ecological challenges.

3.9 Conclusion

This chapter has described the research methodology used in the study. The research approach or design was explained by describing in detail the sample size, the data generation

process and the four analytic phases used to achieve the goals of the study. Phase 1 considered the socio-ecological context of the school and teacher practices; Phase 2 considered curriculum planning, teaching and assessment practices used in the environmental learning; Phase 3 focused on the development and emergence of curriculum competency in informal and formal environmental learning categorised as low, medium and high order questions; and Phase 4 examined the emergence of an integrated approach to developing sustainability competencies in environmental learning.

The chapter also discussed how issues of validity and trustworthiness were addressed in the study through the use of triangulation and interpretive and descriptive validity. Finally, the chapter outlined how ethical questions regarding respect for persons and were addressed. The following chapter presents the data generated by the various research processes outlined in this chapter.

CHAPTER 4: PRESENTATION AND ANALYSIS OF DATA

4.1 Introduction

This chapter presents data which describes the lessons implemented by the four teachers in KwaZulu-Natal in the Midlands area, as well as the specific context in which those lessons were presented. In this chapter the context and the practices of the four teachers are each discussed in four sections. The first section for each teacher presents a contextual analysis which was drawn from the questionnaires and synthesised in Analytical Memo 1. This data contributes to addressing Goal 1 of the study: To investigate the local contextual factors influencing classroom teaching and assessment practices.

The second section for each teacher details the lesson plans through describing curriculum, teacher intentions, lesson activities and teaching methods. This data was generated from lesson plans, lesson observations, interviews and extracts from the Life Sciences CAPS document and synthesised in Analytical Memo 2.1. The investigation of the teaching methods used by teachers in the development of Life Sciences curriculum and sustainability competencies in environmental learning is synthesised in Analytical Memo 2.2. This section addressed Goal 2: To investigate the curriculum planning, teaching and assessment practices.

Data describing assessment practices is presented in the third section for each teacher. This data was generated from informal and formal assessment tasks and synthesised under Analytical Memo 3. This section was aimed at addressing Goal 3 of the study: To investigate the development and emergence of curriculum competency in informal and formal assessment in environmental learning.

The fourth section for each teacher highlights the emergence of sustainability competencies from teaching and assessment practices. These sections are aimed at addressing Goal 4: To investigate the emergence of an integrated approach to developing sustainability competencies in environmental learning processes.

4.2 ZOK school

The data used in this section comes from the ZOK school and teacher profile (ZOKTP), the observation of one lesson conducted in this school (ZOKobserv.1), the one stimulated

interview with the teacher after the lesson (ZOKint.1), the lesson plan (ZOKLP1), an informal assessment task (ZOKAT1) and work from six learners (ZOKLW1).

4.2.1 School context and teacher profile

This school is a farm school and it is a no-fee school. It has an enrolment of 480 learners with 14 teachers thus giving a teacher learner ratio of 1:40. It is a combined school starting from Grade R (5-year-old child) to Grade 12. The learners' home language is isiZulu and the medium of instruction from Grade 4 to 12 is English. The school community is faced with social concerns such as unemployment, illiterate parents and lack of parental support for learners. The teacher reported that the school had no laboratory, and that they experienced shortages of textbooks and furniture (extracted from ZOKTP). She explained that,

> *Especially in my school we do not have resources, we do not have money and we have many learners. So to do practical activities that just becomes a problem.* (ZOKinterv.1// 64-65)

The teacher is qualified and specialised to teach Life Sciences. She has a Senior Teachers' Diploma and has taught Life Sciences for 15 years. In terms of teacher professional development, she attended a CAPS workshop which was organised by the KwaZulu-Natal Department of Education. She found this useful in terms of assessment and methods. She also reported that she had attended a Fundisa for Change workshop organised in the Midlands area and that she gets support from other Life Sciences teachers. She said:

> *As I was saying environmental content is new to me but through working with other Life Sciences teachers and through the help of my subject adviser and also through the [Fundisa] workshop that I attended at Treverton College, I know that there are more methods that you can use in this environmental study lessons.* (ZOKinterv. 1//124-127)

4.2.2 Lesson detail

This section presents the details of one lesson (including curriculum, planning and implementation) that focused on human relations with the environment, namely population ecology (see Appendix 4.1). There were 35 learners in the class and the duration of the lesson was an hour covering the lesson presentation and class activity.

4.2.2.1 Curriculum links and teacher intention

The focus of this lesson was estimating population size which falls within the Life Sciences Knowledge Strand 3 (Environmental Studies). With this topic, 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, p. 49). Population ecology was the main topic with the mark-recapture technique as one of the sub-topics. The teacher's aim for the lesson was twofold: firstly, it was to make learners aware of the impact of human population growth size on the environment. Secondly, the aim was to enable learners to develop investigations skills, namely follow instructions, make estimations, perform simple calculations and apply knowledge of theory to practical situations (see Appendix 4.1). This is evidenced by the following comment from the teacher:

> *Most of my learners are not doing Mathematics. They are doing Mathematical Literacy. Also they are struggling in Mathematical Literacy. So 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.* (ZOKinterv. 1 // 16-20)

4.2.2.2 Description of activities

Activity 1: The teacher explained ways of determining population size, illustrated the mark-recapture technique and the four factors that influence population size: natality, mortality, immigration and emigration (see PLATE 1, Photograph 1).

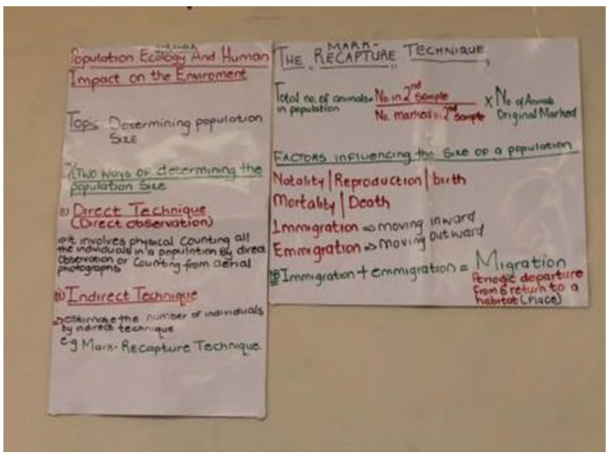
Activity 2: The teacher gave learners an activity to simulate the mark-recapture technique using beans (see PLATE 1, Photograph 2).

Activity 3: The teacher wrote a question relating the increase in population to environmental impact on the board for discussion.

Activity 4: Informal assessment: Learners did an activity on mark-recapture from their textbooks and completed as homework (see PLATE 1, Photograph 3). Photograph 4 shows a learner's response to the activity.

These activities mostly addressed the second objective of the lesson of performing simple calculations and making estimations rather than the first objective of making learners more aware of human population growth size on the environment.

PLATE 1: ZOK School



Photograph 1: *Summary of lesson and definition of concepts*

Photograph 2: *Learner marking the beans to simulate mark-recapture technique*

Photograph 3: *Informal assessment: Learners answering questions on worksheet*

Photograph 4: *Learner's work on mark-recapture technique*

4.2.2.3 Teaching methods

Teaching method 1: Question and answer

The teacher explained the content using the question and answer method. It was mostly used as a strategy to assess learners' understanding and prior knowledge. The teacher did a class activity orally with the learners as an example to show how a population is calculated using

the mark-recapture formula. The following questions were asked to involve learners in the class activity:

> *Teacher: Put your beans together right, and then let us do our practical. What is our aim in this? We are estimating the number of beans by using which method?*
> *Learners: Estimate number of beans, using mark-recapture technique*
> *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.*
> *Teacher: What impact would an increase in population would have on the environment?*
> *Learner: If the population increases, there will be shortage of houses, water, fresh air and food.*
> (ZOKobserv.1//269-539)

Teaching method 2: Using definitions and giving summaries

The teacher provided definitions of concepts to introduce and develop concepts in lessons. For example, for factors influencing population size, words such as natality, mortality, immigration and emigration were defined. Summaries of content knowledge were written on charts for learners to write in their exercise books.

Teaching method 3: Using simulation

The teacher wanted learners to determine the size of a population by simulating the mark-recapture technique. Learners were divided into groups. Each group was given a packet of dried white kidney beans, a plastic bag and a permanent ink marker. Each bean represented an individual in an animal population. Learners took a handful of beans out of the plastic, counted them and marked each one with an X using the marker pen. They recorded the data in a table. The marked beans were put back into the plastic bag and mixed with the rest of the beans. After mixing, a second handful of the mixed beans was taken out from the bag. These were counted as well the number of marked beans in this sample. The total number of organisms in a population was estimated using a given formula.

The activity was repeated four times to find the average estimate of the number of beans. The Life Sciences CAPS document encourages teachers to simulate the mark-recapture technique in order to explain the process of mark-recapture (South Africa. DBE, 2011b p.49).

4.2.3 Emergence of curriculum competencies

In this case, no formal assessment was conducted; only the informal task that was conducted was analysed. Table 4.1 below represents the analysis of the informal assessment task (ZOKAT 1, Appendix 5.1) and associated learners' work (ZOKLW 1 Appendix 5.2). Table 4.1 shows the variety of questions and their cognitive level of curriculum competency. The questions ranged from low order to high order. In analysing this assessment task, competence was categorised according to different cognitive levels as stated in the CAPS curriculum. Low order questions included questions that assess content knowledge, medium order questions assess understanding of science and application of scientific knowledge, and high order questions assess evaluation, analysing and synthesising of scientific knowledge (South Africa. DBE, 2011b).

Table 4.1: Analysis of curriculum competencies and learner achievement in the ZOK informal assessment task

	Cognitive assessment	**Challenges/ task**	**Analysis of learners' work**		
Extract	**Cognitive skill**	**Cognitive level**	**No. of learners**		
			(Level) 5-7	**(Level) 2-4**	**(Level) 1**
1.1 Estimate the total number of grasshoppers in the field. Show all working.	Calculate	Medium	6		
1.2 Suggest two reasons for why the estimated size of the population may differ from the real population size	Suggest a reason	High	4	1	1
1.3 State two ways in which the reliability of this method can be improved?	Discuss	High		6	
2.1 Estimate the population sizes of species B. Show all working	Estimate	Medium	6		
2.2 Estimate the total number of moths in the area. Show all working.	Estimate	Medium	6		
2.3 Suggest why there is a difference in number between species A and B.	Suggest a reason	High	1		5
2.4 Why did the student mark the moths on the undersurface of the animals?	Suggest a reason	High			6

It is noticeable in the table above that the questions focused on medium and higher order cognitive levels with three medium order and four higher order questions. From the table above one can deduce that learners were weakest with the questions that needed deeper reasoning and application of knowledge. This is seen particularly in questions 2.3 (one learner correctly answered the question) and 2.4 (all learners incorrectly answered the question) and partly in questions 1.2 and 1.3. That affirmed what the teacher said in the interview when asked about the curriculum competencies of her learners. She said:

> *Basically they [learners] are good at competencies where one word is needed. Once you say explain, they struggle to support the statement to say why are you saying that ... but why are you doing that becomes difficult.* (ZOKinterv.1//40-42)

4.2.4 Emergence of key sustainability competencies

Section 2.9 defines competence as a functionally linked complex of knowledge, skills and attitudes that enable successful task performance and problem solving with respect to real world sustainability problems, challenges and opportunities (Wiek et al., 2011). The section below describes the key sustainability competencies that emerged from the lesson according to the five sustainability competencies identified by Wiek et al. (ibid).

Systems thinking

Systems thinking was strongly evident in this lesson as seen from the focus on:

- System dynamics when the teacher explained the factors influencing population size (natality, mortality, immigration, emigration and migration). (ZOKobserv.1//84-87)
- Quantitative modelling where learners used a given formula to estimate the size of a bean population – this supported the development of systems thinking competence.

In the calculations, all learners demonstrated competence for quantitative modelling (Table 4.1, Q1.1, 2.1, 2.2). However, five of six learners were not able to answer the interpretive question (2.3) and no learners could answer the critical thinking question on the mark-recapture methodology.

Anticipatory competence

During the lesson the teacher asked learners to explain the impact of an increase of population on the environment (ZOKobserv.1//531-533). Learners anticipated that if the

population increased, there would be a shortage of houses, water, clean air and food (ZOKobserv.1//534).

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 built during the lesson was not helpful in providing the specific systems perspective needed for understanding human-environment relationships.

4.3 DBL school

The data used in this section comes from DBL school and the teacher profile (DBLTP), the observation of one lesson conducted by this teacher (DBLobserv.1), the stimulated interview with the teacher after the lesson (DBLinterv.1), the lesson plan (DBLLP1), formal assessment task (DBLAT1) and learners' work (DBLLW1).

4.3.1 School context and teacher profile

The school is a farm school and it is also a no-fee paying school. It has an enrolment of 297 learners with 13 teachers. It is a combined school starting from Grade R (5-year-old children) to Grade 12 (final year, 18-year-olds). The learners' home language is isiZulu and although the medium of instruction from Grade 4 to 12 is English, the teacher presented her lesson in isiZulu. Only the scientific concepts and notes were written in English. When the teacher was asked in the interview the reason for using isiZulu in her lesson, she responded by saying that learners:

> ... *are growing up into is isiZulu. So it is important for me that when teaching I have to code switch to isiZulu so that they will understand the concepts better.* (DBLinterv. 1// 22-23)

The school had a library although it did not have enough teaching and learning support materials. There were no laboratories but the school had an adequate water supply and electricity. The teacher's highest qualification was a Bachelor of Education (Honours) and she had taught Life Sciences for five years. In terms of teacher professional development, she had attended a CAPS workshop which was organised by the KwaZulu-Natal Department of Education subject advisor. She said she had found it 'a bit' useful and insightful. She mentioned that the methods that she frequently used in her teaching are a textbook approach,

question and answer, and learner-to-learner approach. A challenge she highlighted with the teaching of environmental content knowledge was the lack of teaching and learning support materials. She further mentioned that she sometimes uses a DVD if she happens to find one on environmental concerns. Her other challenge explaining theoretically the content knowledge so that the learners could understand (DBLinterv.1//16). This is evident in her statement:

> *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.* (DBLinterv.1//101-103)

4.3.2 Lesson detail

The class was composed of 35 learners and the duration of the lesson was one hour including a class activity and the lesson presentation. In this section, the detail of one lesson plan was briefly outlined, based on the evidence from data generated through the lesson plan. The lesson plan description outlines curriculum requirements (content knowledge), specific aims and skills followed by a brief description of each activity.

The teacher did not indicate her specific aim for the lesson plan (Appendix 4.2). The resources used were textbooks, chalkboard, chalk, pen, handouts and exercise books. Assessment activities outlined in the lesson plan were verbal questions, peer to peer discussions and a written class activity.

4.3.2.1 Curriculum links and teacher intention

The focus of the lesson was the impact of human population growth on the environment. The curriculum intention was for 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, p. 49). The teacher described her intention for the lesson:

> *The main intention was for learners to know everything that humans do in one way or another affects environment. So we have to preserve the environment. So in order to preserve it we have to know what the human beings do to destroy it so that we can know how to counteract it and to save environment because it is important to us.* (DBLinterv.1//8-13)

4.3.2.2 Description of activities

The activities conducted are briefly described below:

Activity 1: The teacher explained that the increase in human population size places huge demands on the environment in terms of food and deforestation.

Activity 2: The teacher wrote a definition of concepts such as deforestation, photosynthesis, soil erosion and ecological footprint. She added short summaries on the chalkboard and learners took down notes (see PLATE 2, Photograph 5).

Activity 3: The teacher explained the concept of a carbon footprint and gave examples linked to individual impact, family, community, and the country.

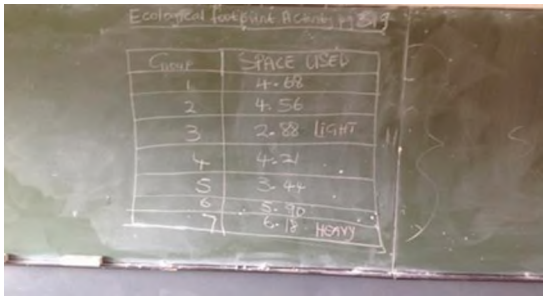
Activity 4: Assessment activity – Learners calculated their individual carbon footprint then added this to other group members (see PLATE 2, Photograph 6). Learners' group scores were written on the board and they discussed who had the heaviest and the lightest carbon footprints (see PLATE 2, Photograph 7).

Activity 5: Formal assessment – Learners were given an assignment on human impact on the environment (see PLATE 2, Photograph 8).

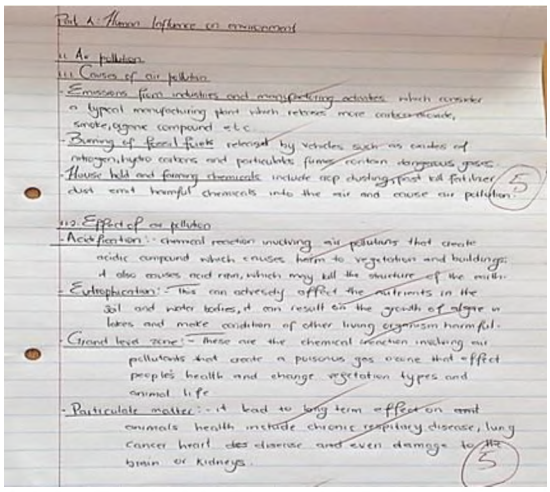
PLATE 2: DBL School

Photograph 5: *Learners writing definitions of concepts*

Photograph 6: *Learners calculating individual footprint (questionnaire)*



Photograph 7: *Groups' scores on ecological footprint questionnaire*



Photograph 8: *Learner's assignment on human impact on the environment*

4.3.2.3 Teaching methods

Investigation

The method that was used by the teacher was an investigation whereby learners explored how individuals' lifestyle choices impact on the environment. A questionnaire was given to learners to calculate their individual footprints, which was then added to other group members' footprints. The learners gave themselves scores on the following questions: "How much water do you use? What kind of food do you eat? How do you shop? Where do you live? How much electricity do you use? How do you get to school? How much paper do you use? How much rubbish do you throw away?" The questionnaire scores were orally presented by groups and were discussed in relation to heavy and light carbon footprints.

Question and answer

The content knowledge was presented through a question and answer method. The questioning and answering was done in isiZulu (home language). Below are a few translated examples of questions used during the lesson:

Teacher*: How do we depend on the environment? Environment being the plants, the soil and other living organisms, how do we depend on them?*
Learner*: We need energy from the plants.*
Teacher*: What do we call the process whereby plants make their own food?*
Learner*: Photosynthesis.*
Teacher*: How is deforestation going to affect the level of carbon dioxide (CO_2) in the air?*
Learner*: By removing trees…*
Teacher*: How will it affect the level of CO_2. 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 CO_2 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.*

When the teacher was interviewed and asked why she mostly used the question and answer method in her lesson, she replied:

> *When it comes to question and answer by the time you ask a learner a question, you stimulate his brain so that he can think. So that he will see that what you teach is not*

something far from his environment. When I teach, I ask a question in between so that a learner's brain will focus on what we are doing. (DBLintev.1//41-45)

Chalk and talk method

The chalkboard was mainly used to write definitions of concepts discussed and short summaries of the facts highlighted. The teacher emphasised the importance of using chalk and talk method:

So, firstly the chalk method helps learners in terms of spelling because a learner can know a lot about environment content knowledge but he cannot be good in spelling. If you have written down the word she will know how to spell it and also understand it. He will never forget it. (DBLinterv.1//37-40)

Local examples

The teacher used family sizes as an example to show the impact of population increase on the availability of resources. This helped to enhance understanding of concepts and content knowledge. She further gave examples from the local environment and incidents to highlight the impact of human population increases such as shortage of burial sites, increase in crime rate and high rate of unemployment.

When the teacher was asked about the challenges she faced in teaching environmental knowledge, she responded by saying that the inability of teachers to expose learners to the environment outside the classroom due to lack of resources such as financial constraints which hinders teachers from taking excursions with learners was a major challenge to her (DBLTP).

4.3.3 Emergence of curriculum competencies

The table that follows outlines the formal assessment questions used.

Table 4.2: Analysis of curriculum competencies in DBL formal task (assignment)

Extract	Cognitive assessment	Challenges/ task	Analysis of learners' work		
			No. of learners		
	Cognitive Skill	Cognitive Level	Level 5-7	Level 2-4	Level 1
A. Human impact on environment Identify 3 examples of environmental influence in your area. Write a report on each influence based on the following sub-topics.					
(a) Its causes	Analyse	High	4	2	
(b) Its effects on the environment	Analyse	High	2	3	1
(c) Ways to reduce the effects	Solve	Medium	1	1	4
B. Water availability Complete the following table to summarise the impact of human activities on water availability in South Africa. Construction of dams Destruction of wetlands Poor farming practices Boreholes Exotic plantations Wastage	Explain	Medium	6		
C. Recycling Do research about recycling and choose one material that can be recycled. Write a detailed report on the process of recycling the material you have chosen. Include photographs or pictures if you can.	Illustrate	Medium	1	4	1
D. Water allocation in South Africa 1. Use the data given in a table above to draw a pie chart	Illustrate	Medium	2	4	
2. What is the environmental reserve?	Define	Low	4		2
3. Explain why South Africa has begun to import water from other countries.	Suggest a reason	High	2		4
4. What is a wetland?	Define	Low	3		3
5. Matching biological terms with definitions	Define	Low	1	3	2

The assignment catered for all cognitive levels. It is noticeable in the table that four of six learners answered question A(c) incorrectly which required a solution and question D(3)

which wanted them to suggest reasons. The section below describes the key sustainability competencies that emerged from the lesson.

4.3.4 Emergence of sustainability competencies

The section below describes the key sustainability competencies that emerged from the lesson.

Systems thinking

The lesson activities covered concepts such as deforestation, ecological footprint and photosynthesis, which required an understanding of human-environment relationships/social-ecological systems.

Table 4.2 (Questions A, B and C) also shows evidence of the development of this competence as learners were expected to mention the influence of human activities on the environment. In Question A four learners achieved between level five and seven and two learners achieved between level two and four. In a discussion of human influences on deforestation, one learner stated that:

> *Agricultural activities – due to ever growing demand for food product, huge amount of trees are fell down to grow crops and for cattle grazing. Urbanisation is where there is more land needed to establish housing and settlement therefore forest land is reclaimed. Fires occur due to extreme warm summers and mild winters. Desertification of land occurs due to land abuse that making it unfit for growth of trees.*

In Question B learners performed well as all sampled six learners achieved between levels five and seven. In Question C one learner achieved between level five and seven, the other four achieved between level two and four and one learner achieved level one, implying that, with some refinement, this competence could emerge.

Anticipatory competencies

Identifying Sustainability Challenges: The lesson covered how population size affects the environment. The teacher highlighted that the increase in human population size would have a negative impact on the environment (plants, the soil, and animals) (DBLobserv.1//3-5).

Causal problem analysis: The teacher analysed the challenge of population increase through elaborating the negative impact it would have on the environment, namely an increase in unemployment rate, crime, death rate, shortage of space, and loss of biodiversity of plants and animals (DBLobserv.1//70-73). This was summarised in the teacher's statement that:

> *After every five years, the survey that is done indicates that the human population is shooting up, but as it increases it affects the environment.* (DBLobserv.1//19-24)

In this lesson, unlike the previous lesson described, there was integration between thinking and anticipatory competencies where firstly, learners were exposed to the concepts of deforestation, and ecological footprints relating to the impact of human population size on the environment. Then, anticipatory competencies were integrated when the teacher described the impact of the increase of population size on the environment. Impacts described included loss of biodiversity (plants and animals) and shortage of space.

4.4 CON school (lesson 1)

The data used in this section came from the CON School and teacher profile (CONTP), one lesson plan (CONLP1), one observation (CONobserv.1) and one stimulated recall interview with the teacher (CONinterv.1). The data also included the one (informal) group presentation and learners' responses. The task was designed by the teacher and given to learners to guide their informal group presentation on the greenhouse effect (CONAT1) as well as the six charts that the six groups used to support their oral presentations (CONLW1).

There were 40 learners in class for the lesson observed. The lesson took one hour 15 minutes due to the large volume of content knowledge covered.

4.4.1 School context and teacher profile

This section describes the case of the CON School teacher, a Grade 11 Life Sciences teacher at a combined school on a farm at Nottingham Road Village. The teacher described the community surrounding his school as one facing social problems such as alcohol abuse, unemployment, poverty and child-headed families. Despite the above-mentioned challenges, the teacher claimed that parents are sometimes supportive of teaching and learning. Elaborating on the availability of resources within the school, the teacher responded in an interview that:

> *Generally, we have teaching resources and we have functional computers, a science laboratory, information technician that is helping out when learners are researching, resources for group work, textbooks and all that. But since we are located around a central area we find that numbers in school will strain the resources. The resources are limited in relation to the numbers of learners that are coming to the school. At a learning level the school is equipped to meet the website and internet needs. At times the parents are supportive of the course of learning.* (CONinterv.2//72-79)

In terms of the infrastructure, the teacher mentioned that the school was not fenced, there was little water but the electricity supply is good. The school was adequately resourced. The teacher specialised in Environmental Sciences at a Cambridge school in Zimbabwe and had a Bachelor's degree in Education. The environmental content knowledge was not new to him as he had learnt it from Grade Five as part of the school curriculum. He was a facilitator of environmental education in 2001 and was involved in agricultural activities. He reported that the environmental education that he studied in Zimbabwe, contributed considerably to understanding the CAPS curriculum. He further mentioned that the nature of his training was hands-on and he was involved in agricultural activities when he was young.

He mentioned that he did not have a challenge with the implementation of CAPS environmental content knowledge as it was related to Natural Science that he covered during teacher training. He attended a one-week CAPS workshop organised by KwaZulu-Natal Ezemvelo. He reported that he encountered challenges especially in those areas that need outdoor activities or use of expensive resources and excursions. He also reported that he gets support from the senior teacher at the school who has been helping him as well as from the resource people who visit the school. The teacher was asked if he experienced any challenges in teaching environmental content knowledge. He responded in an interview that:

> *At the personal level I do not face the challenge as I am being groomed by the senior teacher at the school who has been helping me a lot in this learning area. She is developing me as she is involved in environmental hands-on activities in the school and the resource people [Eco-School facilitators]) who are coming to the school to assist us a lot.* (CONinterv.2//58-62)

In the sections below the detail of the first lesson was briefly outlined based on the lesson plan (CONLP1).

4.4.2 Lesson 1 detail

This first lesson was about human impact on the environment, looking at the current crisis of human survival (CONLP1). Lesson 1 focused on how the greenhouse effect is brought about and how it causes global warming. The lesson plan description outlines the lesson objectives, teacher activities, learners' activities and resources needed (see Appendix 4.3).

4.2.2.1 Curriculum links and teacher intention

The focus of the lesson was the atmosphere and greenhouse effect. With this topic, the CAPS curriculum aims to "emphasise the interrelatedness and interdependence of the human impacts and the environment "(South Africa. DBE, 2011a p.51). The teacher's aim for the lesson was to make learners understand that as they are growing up, they are also part of the universe and it is their responsibility to take care of the environment for the next generation to be able to live like them. The teacher wanted them to realise they are utilising the space and the resources found in the environment (CONinterv.1//6-8). With this lesson the teacher aimed to address the Life Sciences' Specific Aim 1 which relates to knowing the subject content and Specific Aim 3 which relates to understanding the application of Life Sciences in everyday life, as well as understanding the history of scientific discoveries and the relationship between indigenous knowledge and science (South Africa. DBE, 2011a).

4.4.2.2 Description of activities

Activity 1: The teacher explained the direct and indirect impact humans have on the environment as they interact with the environment.

Activity 2: Short summaries and concepts such as greenhouse gases, climate change, human impact and atmosphere were written on the board (see PLATE 3, Photograph 9).

Activity 3: Learners were divided into six groups and different topics were given to each group to present in front of the class as outlined below:

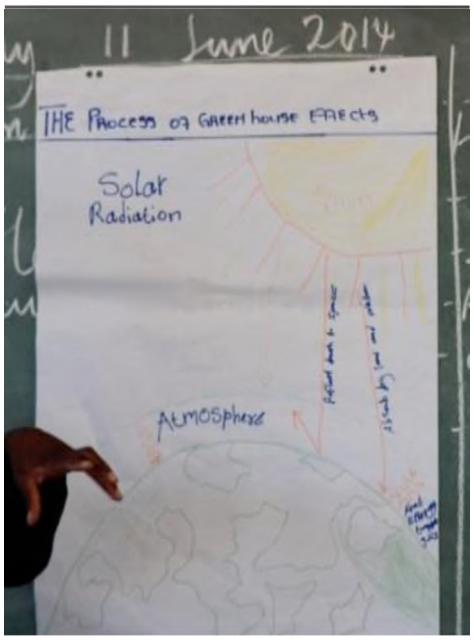
- Group A: Explain the process of the greenhouse effect (see PLATE 3, Photograph 10).
- Group B: Identify greenhouse gases and how they are produced (ozone depletion, methane and carbon emissions).
- Group C: Discuss human activities that produce greenhouse gases
- Group D: Describe the effects of greenhouse gases
- Group E: Anticipate the effect of greenhouse gases in South Africa in 70 years (see PLATE 3, Photograph 11)

- Group F: State and explain strategic ways of creating a sustainable environment. (see PLATE 3, Photograph 12)

PLATE 3: CON School (Lesson 1)

Photograph 9*: Key concepts written on the board*

Photograph 11: *Learner presenting on the effect of greenhouse gases in South Africa in 70 years to come*



Photograph 10: *Learner explains the process of greenhouse effect*

Photograph 12*: Learner presenting strategic ways of creating a sustainable environment*

4.4.2.3 Teaching methods

Using definition of concepts/usage of textbook

In the lesson, the definition of key concepts and short summaries were written on the chalkboard. The teacher identified the new terms and wrote them on the board so that the learners would note the correct spelling and meaning. For example, human impact, environment, atmosphere, climate change, biotic, abiotic and ecology were written on the chalkboard. When the teacher was asked why he used the textbook content knowledge, he said:

> *So it was imperative that we start with the knowledge from the book and also the assumed knowledge that we have in class before they embark on other activities outside the classroom.* (CONinterv.1//56-57)

Question and answer method

Questions were the main mode through which the content was presented to learners. Here are few examples of questions asked during the lesson presentation.

> *Why are we referring to the atmosphere as very important?* (CONobserv.1// 79-80)
> *Who can define the term ecology?* (CONobserv.1// 101)
> *Who can identify some of these greenhouse gases?* (CONobserv.1// 124)
> *How do humans interact with the environment?* (CONobserv.1// 130)

The teacher stated that he used this method mainly to assess the prior knowledge that learners had gained throughout the study from senior phase to the secondary phase (CONinterv.1// 63-64).

Group discussion

This method was used for learners to further elaborate on particular concepts and prepare for presentations that would follow. No marks or rubric were used to assess presentations as this was an informal activity intended to actively involve learners in the lesson. Learners used the Life Sciences textbooks to access knowledge for this group activity. Flipcharts were given to groups to write down their responses for presentation tasks. The teacher's aim for using this method was to:

> *Give them chance to present and show if they have expressive skills to demonstrate knowledge on areas that were asked in the lesson.* (CONobserv.1// 64-66)

Scenario planning

The teacher gave learners a scenario where they were asked to think about and anticipate the unknown future through observing what was happening in the scenario (Activity 3, group E). They were asked to predict what would happen in 70 years and to develop a strategy on how

to mitigate the situation. This method helped to stimulate critical understanding of what sustainability means in their context.

4.4.3 Emergence of curriculum competencies

In Table 4.3 below, the group presentation was analysed, according to cognitive skills and cognitive levels that emerged. The teacher divided learners into six groups and each group had a different question to discuss and present to the whole class.

Table 4.3: Analysis of curriculum competencies in the CON Informal assessment task 1

Extracts	**Source**	**Cognitive assessment**	**Challenges task**
		Cognitive skill	**Cognitive level**
Group A: Discuss the process of greenhouse	CONobserv.1//148	Discuss	High
Group B: Name greenhouse gases and [explain] how they are produced.	CONobserv.1//148	Name	Low
		Explain	Medium
Group C: Explain human activities that produce greenhouse gases	CONobserv.1//150	Explain	Medium
Group D: Discuss the effects of greenhouse gases	CONobserv.1//152	Discuss	High
Group E - South Africa in 70 years will have a temperature rise of about 3 degrees Celsius. Calculate the annual rise over the given period of time. Predict the effects of such a phenomenon to South Africa in 70 years.	CONobserv.1//154-156	Calculate	Medium
		Predict	Medium
Group F: Suggest strategic ways of creating a sustainable environment, for example, use of green technology.	CONobserv.1//159-160	Explain	Medium

Learners' responses to the above group task

The task above was analysed differently from other learners' work because there was no rubric or assessment guidelines used (see Section 3.5.3). In Group A, the presenter explained the greenhouse effect. He said:

> *As it goes to the earth, it goes through the atmosphere where it gets gases such as carbon dioxide, methane, chloroform carbons (CFCs) and heats them. The*

abovementioned gases will get hot and heat the atmosphere, which is why it is called global warming. (CONobserv.1//235-259)

The Group B learners discussed how greenhouse gases are produced. The presenter explained:

Nitrogen oxide breaks down organic matter in the soils and they have CFCs which are aerosol sprays and industrial cleaning materials. (CONobserv.1//207-209)

The Group C learners presented human activities that produced greenhouse gases. The presenter explained activities such as burning of fossil fuels, deforestation, littering, use of fertiliser by farmers as well as the use of aerosol sprays. The presenter for the group explained that by aerosol sprays he meant perfumes that are not ozone friendly (CONobserv.1//178-186).

The Group D learners presented the effects of greenhouse gases. The learners explained that greenhouse gases cause global warming, climate change, desertification, and floods that leave some people without homes (CONobserv.1// 216-220).

The Group E learners anticipated the effect of greenhouse gases on South Africa in 70 years. Learners first calculated the annual rise of temperature from the scenario given by the teacher. They found that the temperature increases by 0, 04 degrees Celsius per year. The learners further explained that, with the increase in the South African population, more coal will be burnt to generate electricity and that will increase the emissions of carbon dioxide into the atmosphere. Learners also mentioned that the rise in temperature will cause sea levels to rise that will result in floods and melting of ice (CONobserv.1// 293-330).

The Group F learners presented strategic ways of creating green technology. Learners suggested the use of water in generating electricity because water can be reused rather than using coal. They also suggested the use of solar panels to generate electricity (CONobserv.1//353-362).

4.4.4 Emergence of sustainability competencies

In this section the key sustainability competencies that were developed during the lesson presentation are highlighted.

Systems thinking

Identifying Sustainability Challenges: The teacher explained that humans have a direct and indirect impact on the environment as they interact with living and non-living organisms. In this activity, Group C described the human activities that produce greenhouse gases, namely burning of fossil fuels, decomposition, forest fires, use of nitrogen fertilisers and use of chlorofluorocarbons (CFCs) in sprays (see Section 4.4.2.4). In their presentation they focused on basic causes (human activities) and the effect of a sustainability problem (greenhouse gases on the environment). Group C further explained the effects of greenhouse gases by stating that:

> *It causes global warming, climate change, desertification, floods, high and low temperatures and winds.* (CONobserv.1//217-218)

Learners were able to make connections between the ideas and concepts, for example, they knew that humans are producing substances that trap heat so that it is not released. Group D was given an opportunity to analyse the process of greenhouse effect (explain how it happens). They explained that:

> *The sun is generating heat energy, and that heat energy goes to the earth where it will be reflected into the atmosphere, scattered and absorbed.* (CONobserv.1//276-277)

This understanding is not entirely correct. Actually, the sun produces light (or radiant) energy, which is absorbed when it hits the Earth's surface and is emitted as infrared energy (or heat).

The teacher further elaborated that:

> *Human activities are not only generating temperature (heat) but also producing substances that trap the temperature so that it is not released. When heat is trapped on earth, the ozone layer will start to have holes that allow a lot of sun to come directly to the earth which is not good for biodiversity because we have organisms that cannot tolerate high temperatures.* (CONobserv.1// 278-289)

Group E discussed different sectors in South Africa that would contribute to the increase of carbon dioxide in the atmosphere namely, coal industry, agriculture, health, sea level rises and transport system (CONobserv.1//319-335). The foregoing discussion revolved around systems thinking competence.

Anticipatory competencies

The teacher gave Group E a scenario-like task:

> *In the next 70 years, temperatures in South Africa could rise by 3^0C causing a 10% decrease in rainfall, making already dry areas desert-like.* (CONobserv.1//155-157)

Group E was expected to calculate the annual rise of temperatures over a given period of time and anticipate how the increase of carbon dioxide in the atmosphere would impact on the environment. The presenter concluded thus:

> *There will be unpredictable diseases and let us save South Africa. Let us think of the future generations.* (CONobserv.1//337-338)

Strategic competencies

Group F discussed ways to mitigate the effects of greenhouse gases on the environment. Learners strategised how human activities might contribute to future sustainability problems (greenhouse gases).

> *We can find another source to produce electricity, like water because we can re-use rather than coal which we cannot reuse. We can introduce solar panels, and green technology.* (CONobserv.1//353-360)

Integration of sustainability competencies is noticeable in this lesson when learners explored different factors that contribute to greenhouse gases (systems thinking), calculated predicted temperature rises over time and the potential effect on the environment (anticipatory thinking), and crafted a vision for renewable energy in South Africa (strategic competence). Although, not every group was challenged to develop the same competencies as the whole class, there was potential to see the integration of these presentations and the potential to develop integrated competencies if learners were focused on the topic and on their peers' presentations.

4.5 CON school (lesson 2)

The data used in this section came from the CON School second lesson (CONLP2), one observation (CONobserv.2) and one stimulated recall interview with the teacher (CONint.2). The data was drawn from one informal oral presentation and one written formal assessment task (CONAT2). The data included:

- The written task designed by the teacher and given to learners to guide their informal group presentation on food security (CONAT2) as well as the six charts that the six groups used to support their oral presentations (CONLW2).
- The verbal instructions given to learners to guide them on the formal research assessment assignment on food security (CONAT3) as well as six examples of learners' work representing different levels of achievement (CONLW3).

There were 40 learners in class in the lesson observed.

4.5.1 School context and teacher profile

This section was elaborated in the first lesson (see Section 4.4.1).

4.5.2 Lesson detail

This lesson was also about human impact on the environment, looking at current crises for human survival (CONLP2). Lesson 2 highlighted factors that affect food security such as exponential growth of the human population, droughts and floods (in turn affected by climate change), poor farming practices, alien plants and reduction of agricultural land. It was an hour-long lesson according to the lesson plan but it took one hour and 30 minutes due to the large volume of content and class activities that were planned.

4.5.2.1 Curriculum links and teacher intention

The focus of the lesson was on food security which is another topic under 'Human impact on the environment' under Knowledge Strand 3: Environmental Studies. With this topic, CAPS "emphasises the interrelatedness and interdependence of human impacts and the environment" (South Africa. DBE, 2011a, p. 51). The teacher intended learners to see the need to look at food security as a major factor that is directly related to the use of natural resources in the environment (CONinterv.2//14-15). A Life Sciences Specific Aim the teacher addressed was Specific Aim 1 that relates to knowledge understanding and Specific Aim 3: Understanding the applications of Life Sciences in everyday life as well as the relationships between indigenous knowledge and science (South Africa. DBE, 2011a, p.13).

4.5.2.2 Description of activities

Activity 1: The teacher explained the importance of food and the concept of food security.
Activity 2: The teacher handed out a local newspaper and learners were asked to look in the

advertorial insert for prices of the food types they use on daily basis (see PLATE 4 Photograph 14).

Activity 3: Learners read and discussed an article in the local newspaper in which local farmers raised concerns about veld fires and drought and the impact on food production.

Activity 4: Learners discussed the impact of human exponential growth on food availability based on the content knowledge in Life Sciences books (see PLATE 4, Photograph 14).

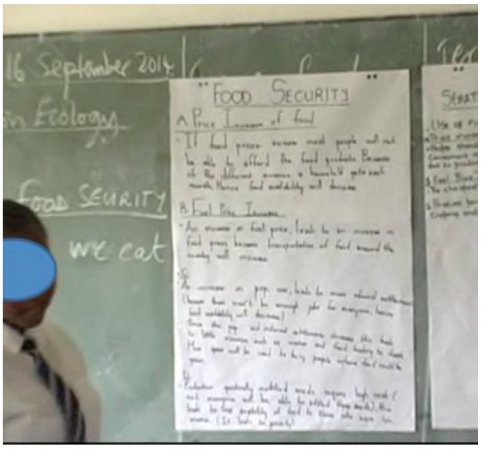
Activity 5: Informal assessment: Learners broke into six groups to work on the following tasks:

- Group A: Explain the impact of exponential human growth on food security.
- Group B: Explain how natural environmental occurrences can impact on food security.
- Groups C and D: Explain how the agricultural sector had impacted on food security looking at aspects such as monoculture and use of fertilisers.
- Group E: Anticipate how a selection of different economy sectors could contribute to food insecurity. For example, fuel price increase, poverty, food price increase and monopoly of seed production.
- Group F: Identify intervention measures that can be taken to address the problem of food insecurity in South Africa (see PLATE 4, Photograph 15). Life Sciences and Geography textbooks were used to deepen their knowledge on the topic.

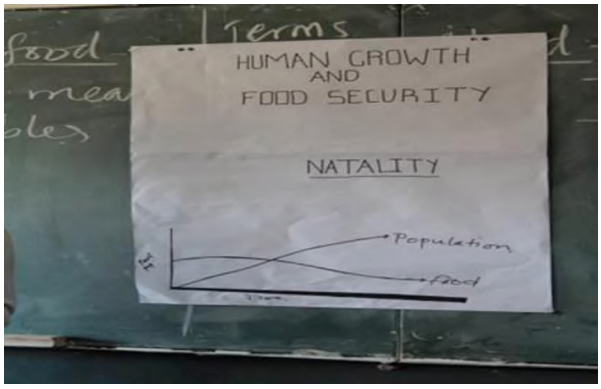
Activity 6: Learners were given an assignment to do research on how Chimanimani in Zimbabwe used permaculture farming to mitigate food security problems (see PLATE 4, Photograph 16). The task was given verbally and there was no rubric for assessment.

PLATE 4: CON School (Lesson 2)

Photograph 13: *Learners looking at food prices in the newspaper*



Photograph 15: *Learners presenting measures that can be taken to mitigate food security in South Africa*



Photograph 14: *Graph showing impact of human exponential growth on food availability*

Photograph 16*: Learner's research on Chimanimani permaculture project in Zimbabwe*

4.5.2.3 Teaching methods

Question and answer

Questions and answers was used as a baseline assessment to assess the level of learners' understanding of concepts. Answers and definition of concepts were discussed and written on the board: population, need, food security ecology and human impact.

Case study

In Activity 3, the teacher gave learners a clipping from the local newspaper to present the sustainability concern of the local farmers about food security. The teacher used this method

to conscientise learners regarding the impact of human activities and to reflect on the implications of these activities on the environment. The teacher also gave learners a case study about Chimanimani permaculture programme to research.

Presentation

Groups were given tasks to discuss and develop presentations. Learners were given charts and koki pens to write down their points.

4.5.3 Emergence of curriculum competencies

Table 4.4 below is an analysis of the level of questions used during the informal group research task (Activity 5) given to learners in order to prepare for their formal research task. It is noticeable that most of the questions asked during the lesson were of a medium order, one was of a high order and three of a low order. Learners' command of English was good and they also displayed good presentation skills and showed good understanding of the relationship between humans and food security.

Table 4.4: Analysis of curriculum competencies in the CON informal assessment task 2

Extracts	**Source**	**Cognitive assessment**	**Challenges task**
		Cognitive skill	**Cognitive level**
Group A: Explain briefly how human growth pattern impacts on the food security	CONobserv.2//179-181	Explain	Medium
Group B: Explain how natural occurrences like drought, floods, climate change can affect food security	CONobserv.2//231-232	Explain	Medium
Group C and D: Name four poor farming methods and discuss how each contributes to food insecurity. Define monoculture and explain how is it linked to food insecurity?	CONobserv.2//294-295 CONobserv.2//308	Name Discuss Define Explain	Low High Low
Group E: Predict how petrol prices will contribute to food insecurity in South Africa	CONobserv.2//341	Predict	Medium
Group F: Identify intervention measures that can be taken to address the problem of food insecurity in South Africa	CONobserv.2//357-358	Identify	Low

The task above was also analysed differently from other learners' work because no rubric or assessment guidelines were used (see Section 3.5.3).

Group A learners interpreted the graph (see Photograph 14) by stating that at the start of the graph the human population was low and the food supply was plenty, but as the population increased, food supply decreased. They further highlighted that the increase in population resulted in more farming land being used for building houses that also resulted in more resources used (CONobserv.2//188-196).

Group B explained how natural occurrences such as drought, floods, climate change can affect food security. Learners defined these concepts and further elaborated that floods wash away topsoil causing the soil to be infertile resulting in food insecurity. The learners mentioned that climate change would have a negative impact on the growth of plants (CONobserv.2//235-248).

Groups C and D explained four farming methods and their contribution to poor food security. The farming methods that were mentioned were monoculture, overgrazing, use of fertiliser and the use of pesticides. Learners explained that monoculture reduces soil nutrition and therefore reduces food supply. The use of pesticides has a negative impact on top soil, decreasing its nutritional value. They stated that overgrazing causes desertification that results in soil losing its topsoil. They explained that the use of fertiliser produces a lot of food in the shortest time (CONobserv.2//294-314).

The group E presenter explained how the increase in food prices affects food availability in the country. The presenter explained that if food prices increase, this results in less availability of food, as the majority of the people cannot afford to buy food due to low household income. The presenter for the group also mentioned that the increase in petrol price results in the increase of food prices due to food transportation costs (CONobserv.2//329-401).

The Group F learners suggested permaculture practices as a strategy to secure food for everyone.

The group presentations were followed by a formal assessment task which was a research assignment on Chimanimani permaculture project. The teacher gave the task verbally:

Go to the computer room and download this information. What is happening to Chimanimani area? You go and type this word 'Chimanimani' and 'permaculture'. Research on food security Chimanimani-Zimbabwe permaculture-Tsuro permanent culture. (CONobserv.2//410-417)

In the absence of a detailed assignment, this task was treated differently from the others. Instead it was analysed according to the cognitive skills and levels that emerged in the learners' research assignments as well as the competencies that emerged. The extracts were taken from two learners' work because others simply downloaded information from the Internet and submitted this. Learners who downloaded material did not work substantively on the material and this made it impossible for analysing as there were no emergent cognitive skills to analyse. The extracts below display the cognitive skills and cognitive level that emerged from the assignment.

Table 4.5: Analysis of curriculum competencies in the CON formal assessment task 3

Extracts	**Cognitive assessment**	**Challenges/ task**
	Cognitive skill	**Cognitive level**
Tsuro holds regular workshops and meetings, promoting key permaculture technique such as integration of livestock and crop management. Tsuro also promote the use of nitrogen-fixing plants as an organic and low-cost method of soil enrichment	Explain	Medium
The first Chikuwa workshop: The community and interested farmers were invited to the training. The community agreed to prioritise water retention protection of the spring from cattle and goats and to plant trees on the hilltop catchment.	Explain	Medium
One of their most inspiring project is the community health initiative, Zunde Tamambo, which bring the permaculture principle of caring for people's lives by promoting the community support for vulnerable individual (such as orphans and elderly) by cultivating food crops on special plots of land on their behalf.	Explain	Medium

The abovementioned cognitive skills were highlighted from learners' assignments as their responses were in an explanatory form, explaining how the community engaged in decision-making and action plans to develop permaculture gardens.

4.5.4 Emergence of key sustainability competencies across CON informal assessment task 2 and formal task (assignment)

Systems thinking

The teacher and learners analysed the sustainability problem (food security) by discussing the dynamics across the multiple domains, namely society (exponential increase of human population), natural occurrences such as droughts, floods, climate change (environment) and the rise of petrol and food prices (economy) as well as the use of fertilisers by farmers (technology) which are related to food insecurity. The teacher highlighted the cause-effect relationship of the problem through mentioning that: "As the human population increases, more food is required" (CONobserv.2//195). The teacher explained the interrelationships between living and non-living things and how living things impact on food availability at a local level (farms around the area), South Africa and the world as a whole. He accentuated this point when he said:

> *If you read carefully in your newspaper there, you can see that there are some aspects that are making South Africa not to get enough food, as in Midlands certain environmental conditions affect food production.* (CONobserv.2//124-126)

Anticipatory competence

The learners anticipated that as the human population increases, the following challenges would be experienced: poverty and a high unemployment rate. The learners identified poverty in the country as the main cause that leads to a high birth rate. They also noted that the shortage of food locally will lead to high demand thereof, which may lead to food price hikes. Furthermore, they argued that the retailers and consumers might have to buy food from remote areas which will have an impact on fuel cost. This could lead to further food price increases to cover transport costs (CONobserv.2//342-350). In the formal task, the following competencies emerged:

Interpersonal competence

Learners read and wrote about Chimanimani community engagement with issues of sustainable food security as well as ways to enrich the soil. Learners highlighted the importance of collaboration and effective communication towards a common goal that was mutually beneficial to community members that resulted in the success of permaculture project. The realisation of the importance to engage in collaborative decisions by learners, revealed the development of this competence.

Strategic competence

Only one case of strategic competence development was evident in the learners' assignments, as they read and wrote that the community took action to retain spring water by planting trees on the hilltop catchment. Learners highlighted the importance of taking action to achieve the goals that make a community sustainable vision happen.

Normative competence

In one of the learner's work it became evident that the learner read and wrote that the community members developed permaculture gardens for the elders and orphans. This showed a stronger sense of responsibility within the community members. This was appreciated by the learner in an assignment which indicated the development of normative competence.

It was noticeable that five sustainability competencies were integrated across the two tasks mentioned above (informal task 2 and formal task). The understanding of environmental issues (systems thinking), anticipation of environmental problems (anticipatory competence), importance to engage in collaborative decision (interpersonal competence), the significance of taking action in achieving goals (strategic competence), the appreciation of the community's responsibility to care for elders and orphans (normative competence).

4.6 TON school

The data used in this section comes from the TON school and teacher profile (CONTP), the lesson observation (TONobserv.1), the additional questionnaire (TONIC1) after the lesson, the lesson plan (TONLP1), informal assessment task (TONAT1) and formal assessment task (TONAT2) and learners' work (TONLW1 and TONLW2).

4.6.1 The school context and teacher profile

This section describes the case of the TON School teacher – a Grade 11 Life Sciences teacher at a farm school in the Midlands area in KZN. The school is situated on a 1200 hectare farm. The school is an Agricultural College and it is an ex-model C school with 80 learners. The teacher described the community surrounding his school as one that lacks motivation especially the learners. In terms of the infrastructure, the teacher mentioned that the school is in very good condition and is well resourced. The teacher specialised in Life Sciences, has 28 years teaching experience and has a Higher Diploma in Education. In terms of teacher

professional development, he attended a CAPS workshop which was organised by the KwaZulu-Natal Department of Education. He said it was good and mentioned that he was privileged as he could use the farm as a context to relate to environmental problems. He further mentioned that he used a variety of teaching methods in teaching environmental topics.

4.6.2 Lesson detail

In this section the detail of the one lesson plan is briefly outlined (based on evidence from the lesson plan and observation). The lesson plan focused on water quality. The lesson was about the impact of human activities on water availability and quality, focusing on the current crisis for human and animal survival (see Appendix 4.5). There were eight learners in the class and the lesson was an hour. The lesson included presentation of content knowledge and the filling in of worksheets.

4.6.2.1 Curriculum links and teacher intention

The focus of the lesson was the impact of human activities on water quality and availability. This lesson features under Knowledge Strand 3 (Environmental Studies). Under this topic, the CAPS curriculum intends to "emphasise the interrelatedness and interdependence of human impacts and the environment" (South Africa. DBE, 2011a, p. 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. The lesson was also intended to address Life Sciences Specific Aim 1 (knowing the subject content) and Specific Aim 2 (investigating phenomena in Life Sciences) (South Africa. DBE, 2011a, p.13). The visit to a local river (Activity 1) below responded to an assessment requirement stipulated by the curriculum where learners are expected to do a practical observation of one example of human influence on the environment in the local area (South Africa. DBE, 2011a, p. 51).

4.6.2.2 Description of activities

The activities conducted to address these curriculum objectives are described below:

Activity 1: Fieldwork (Site 1 – River). The teacher took the learners to a local river to observe and discuss human impact on water quality between the weir to a point eight kilometres down the river. They drove along the river, discussed and compared the two parts of the river. Activities 2 and 3 below were between the two points mentioned above.

Activity 2: Fieldwork (Site 2 – Textile factory). The teacher showed the learners the textile factory pump that pumps water from the river to the machines and back to the river and explained the state of water from the factory that was clean but hot (thermopollution) (see PLATE 5, Photograph 17).

Activity 3: Fieldwork (Site 3 – Sewage farm). The teacher stated that sewage was a big problem. He explained how the local municipality purifies sewage water and the challenges the municipality has with the leaking sewage pipes that go straight into the river (see PLATE 5, Photograph 18). He further explained that the municipality was doing something to solve leaking pipes.

Activity 4: The teacher summarised the lesson at the sewage farm by emphasising the impact of human activities on plant and animal biodiversity such as poor farming practices, exotic plantations and destruction of wetlands, as well as the importance of clean water in the human body. One learner anticipated the risk of cholera that might occur by drinking polluted water.

Activity 5: The teacher asked learners to come up with a solution to this problem of poor water quality. This was informally discussed and one learner mentioned that 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.

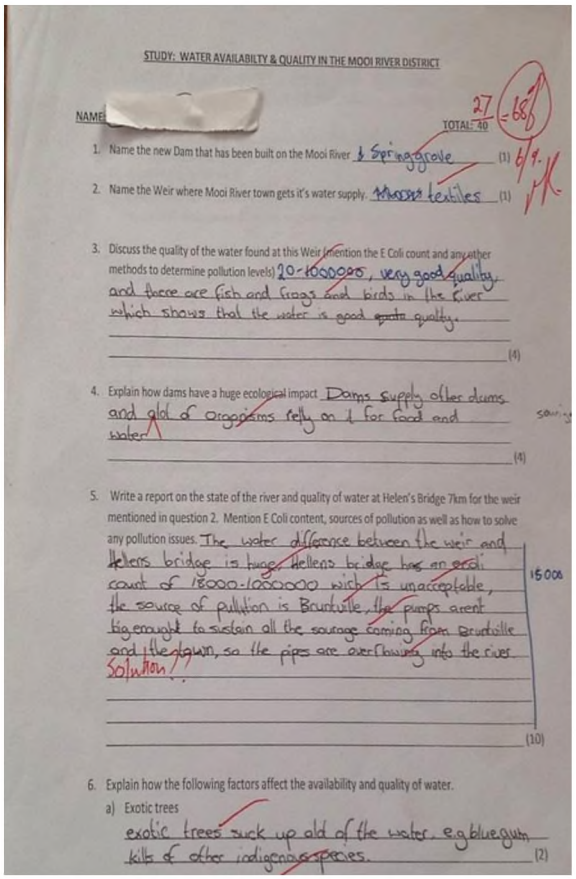
Activity 6: Informal Assessment: Worksheet – learners filled in answers on a worksheet during the lesson presentation at the site and completed it as homework (see PLATE 5, Photograph 19).

These lessons covered the content knowledge that learners were expected to know such as farming practices, exotic plantations, destruction of wetlands, need for water purification on water availability (Activity 2-4). They also covered the content knowledge in their observations of the eight kilometre drive along the river.

PLATE 5: TON School

Photograph 17: *Site 2 – Textile factory*

Photograph 18: *Site 3 – Sewage farm*



STUDY: WATER AVAILABILTY & QUALITY IN THE MOOI RIVER DISTRICT

NAME: [redacted]

TOTAL: 40

1. Name the new Dam that has been built on the Mooi River. Springrove (1)
2. Name the Weir where Mooi River town gets it's water supply. Mooi textiles (1)
3. Discuss the quality of the water found at this Weir (mention the E Coli count and any other methods to determine pollution levels) 20-1000000, very good quality and there are fish and frogs and birds in the river which shows that the water is good quality. (4)
4. Explain how dams have a huge ecological impact. Dams supply other dams and alot of organisms rely on it for food and water (4)
5. Write a report on the state of the river and quality of water at Helen's Bridge 7km for the weir mentioned in question 2. Mention E Coli content, sources of pollution as well as how to solve any pollution issues. The water difference between the weir and Hellens bridge is huge, Hellens bridge has an ecoli count of 18000-1000000 which is unacceptable, the source of pollution is Bruntville, the pumps arent big enough to sustain all the sewage coming from Bruntville and the town, so the pipes are overflowing into the river. Solution: (10)
6. Explain how the following factors affect the availability and quality of water.
   a) Exotic trees
   exotic trees suck up alot of the water. eg bluegum, kills of other indigenous species. (2)

Photograph 19: *Learner's worksheet on water quality and availability*

4.6.2.3 Teaching methods

Investigative method (experiential learning)

The main method for this lesson was fieldwork which involved a visit to a local river to observe and discuss quality of water from the weir to eight kilometres down the river and learners were given worksheets to fill in the answers. The teacher showed and told learners how humans negatively impact the quality of water (show and tell method). The teacher elaborated on the reason for using this type of method:

> *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 to them.* (TONCI no.9)

Question and answer

The question and answer method was used to mediate the content knowledge. During the lesson learners were involved by answering questions. They defined scientific concepts related to the content knowledge

4.6.3 Emergence of curriculum competencies and learner achievement in TON informal assessment task (worksheet)

In Table 4.6 below, the informal assessment task was analysed, according to cognitive skills and cognitive levels that emerged. It is also about learner achievement at the different levels.

Table 4.6: Analysis of curriculum competencies in the TON informal assessment task

	Cognitive assessment	**Challenges/ task**	**Analysis of learners' work**		
			No. of learners		
Extracts	**Cognitive skill**	**Cognitive level**	**(Level) 5-7**	**(Level) 2-4**	**(Level) 1**
1. Name the new dam that has been built on the area	Name	Low	6		
2.Name the weir where local River gets its water supply	Name	Low	6		
3. Discuss the quality of water found at this weir (mention the *E.coli* count and any other method to determine pollution levels)	Discuss	High	6		
4. Explain how dams have a huge ecological impact	Explain	Medium	6		
5. Write a report on the state of the river and quality of water at Helen's Bridge 7 km from the weir mentioned in question 2. Mention *E.coli* content, sources of pollution as well as how to solve any pollution issues.	Solve	Medium	6		
6. Explain how the following factors affect the availability and quality of water: (a) Exotic trees (b) Destruction of wetlands (c) Poor farming practices (d) Irrigation e.g. centre pivots	Explain	Medium	4	2	

7. Write a report on Weston's water management including the following factors. Sources of water, quality, conservation of water, management of liquid waste and if problems are discovered, provide realistic solutions (a digital report with photos will be accepted).	Explain Solve	Medium		6	

The informal assessment was a worksheet about their study of water quality and availability in the local river. Of the seven questions, one was of a high order, two were of low order and the other four were of a medium order. The cognitive levels were not distributed according to CAPS requirements (see Table 2.2).

In addition, the formal assessment (class test) was also analysed together with the learners' work according to their performance per question in relation to cognitive skill and cognitive level of each skill. From Table 4.6 below, it is evident that learners had challenges in the calculations (question 2.3) and understanding of concepts and processes (question 3.5). Nine questions were of a low order, eight questions of a medium order and four questions were of a high order. Learners' performance in questions 2.3 to question 2.5 showed some challenges in understanding what was required by the action verb such as 'explain' used in questions as well as conceptual understanding. Some learners failed to suggest reasons in question 2.6. The test showed fair distribution of cognitive skills. They met curricular weighting of cognitive demands (see Table 2.2). The learners' performance was good in terms of addressing different cognitive levels and cognitive skills.

Table 4.7: Analysis of curriculum competencies in the TON formal assessment task (Test)

	Cognitive of assessment	Challenges task	Analysis of learners' work		
			No. of learners		
Extracts	**Cognitive skill**	**Cognitive level**	**(Level) 5-7**	**(Level) 2-4**	**(Level) 1**
1. Give the correct biological term for each of the following:					
1.1 The cultivation of plant population of a single species	Define	Low	5		1
1.2. Chemicals used to kill pests			6		
1.3. The fertile upper layer of soil			6		
1.4. Plants that are not indigenous to an area and spread quickly replacing indigenous plants			6		
1.5. Human waste consisting of urine and faeces			5		1
2.1. Illustrate the data in the above table	Illustrate	Medium	6		
2.2 Describe ozone layer depletion	Describe	Low	3		3
2.3 Calculate number of years taken for ozone layer to triple	Calculate	Medium	2		4
2.4 How much ozone was lost from the stratosphere in 1994	Read the table	Low	3		3
2.5 Are CFCs immediately removed from the atmosphere when you stop using them? Explain your answer.	Explain	Medium	2	2	2
2.6 After 1994 the ozone depletion decreases. What do you think was the reason for this decrease?	Suggest a reason	High	1	2	3

3.1 Define the term greenhouse effect	Define	Low	1	3	2
3.2 Name one way the greenhouse effect benefits the earth	Name	Low	4		2
3.3 Explain the effects of global warming	Explain	Medium	5		1
3.4 Explain the difference between afforestation and deforestation	Explain	Medium	6		
3.5 What is the main cause of desertification in South Africa?	Explain	Medium			6
3.6 Why is it necessary to manage natural resources in a sustainable way?	Suggest a reason	High	3	3	
4.1 Explain what over utilisation means?	Explain	Medium	2	1	3
4.2 What do you think makes rhino poaching different from other forms of poaching?	Differentiate	High	4	2	
4.3 What is meant by subsistence poaching?	Define	Low	4		2
4.4 What gas can be harvested or recovered from landfill sites and used as energy source?	Name	Low	4		2
4.5 Name two sustainable energy sources	Name	Low	4	2	
4.6 Water quality is rapidly becoming a more critical problem that water availability in South Africa. Why is this case?	Suggest a reason	High	2	2	2
4.7 Explain the importance of carbon sinks	Explain	Medium	2 4	3	12 2
4.8 Give an example of carbon sink	St State	Low	6		

4.6.4 Emergence of key sustainability competencies

Systems thinking

The sustainability challenge identified in this lesson was the impact of human activities on water availability and quality. The teacher explained the impact of society, economy and technology on water availability and quality. The teacher explained to learners the history of the river, the catchment area, and the dams, as well as the wetlands and their role in sustaining water quality.

The teacher asked learners to compare the state of water between a point at its source, and a point where human activities had impacted on its quality. Learners applied their theoretical knowledge to a real problem where they studied various processes that negatively impact on the quality and availability of water, namely thermo-pollution from a local textile factory, poor farming practices and leaking sewage which all cause harm to biodiversity. The teacher claimed that the *E.coli* count of the water from its source was 20 per million. He emphasised the importance of water to the human body stating that about 65 percent of the adult body is water. He stated that:

> *Water is just more important than the food we eat, seriously, because it makes 65% of your body fluid.* (TONobserv.1//261-263)

From the informal assessment activity, it was evident that most learners were able to demonstrate systems thinking as most of them achieved between levels five and seven (Table 4.6). One learner's response to Question 5 was:

> *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.*

In the formal task, there was an evidence of systems thinking emerging as in Table 4.7 question 4.2 (What do you think makes rhino poaching different from other forms of poaching?); four of six sampled learners achieved between levels five and seven, and the other two learners achieved between levels two and four. One learner's response to the question was:

In most cases the rhino's horn is taken and the body is left there to die. In normal farms of poaching they use bushman poaching. People poach because they are poor and they need the food whereas rhino poachers take the horn for profit.

Anticipatory competence

Learners anticipated diseases like cholera that 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. Little kid can fall and swallow this water. (TONobserv. 1// 174- 175)

Strategic competence

The teacher mentioned that the local municipality was trying to do something about the issue of leaking sewage pipes. He also appealed to learners to come up with a solution to minimise water problems (TONobserv.1// 176-177). It was evident in learners' work that this competence was developed as six learners for Question 4 achieved between levels five and seven in the informal task. However, in Question 7 (Write a report on Weston's water management), all six learners achieved between levels two and four (Table 4.6).

When responding to Question 7 of the informal task, a learner a suggested a strategy that could be taken to address the issue of liquid waste of (Table 4.6). This learner stated that:

We can prevent this by revamping smaller pipes into bigger ones. Restrict dumping from the river.

In this lesson, integration of three sustainability competencies were supported when the teacher highlighted the impact of society, economy and technology on quality and the availability of water (systems thinking). He further highlighted the plans (strategic) of the municipality to fix leaking pipes and he urged learners to come up with a solution to avoid water challenges in the area. Learners predicted the type of diseases that might arise due to poor quality of water (anticipatory).

4.7 Conclusion

This chapter has described the challenging socio-economic contexts in which the four teachers participating in the study were working. The three community contexts displayed

aspects of poverty and unemployment and one school had a water availability challenge. All four teachers were qualified to teach Life Sciences. Three of them had a Bachelor of Education degree and one had a teacher's diploma. Three teachers taught Zulu-speaking learners and the fourth taught multi-lingual learners in an ex-model C school. Three of the teachers noted a shortage of resources such as textbooks, library and financial constraints for taking learners out for an excursion. The methods used by the teachers were demonstration, investigation, researching information from the Internet and a case study (newspaper article). One teacher took his learners for a fieldwork study of water quality in the local river. A textbook was mostly used by three teachers for delivering the new content knowledge. Assessment tasks given to learners were drawn from the textbook by three teachers and the fourth teacher's task was research work using the Internet.

All four teachers gave informal assessment tasks during lessons, and three presented a formal task. Formal assessments were given in the form of assignments – one was on food security another on human impact on the environment and one class test focused on human impact. The assessment tasks displayed a variety of cognitive levels ranging from low to high order questions and some learners experienced challenges with the high order questions, especially with questions where they were requested to give reasons. The key sustainability competencies such as interpersonal and normative were not strongly evident in the lessons. Three teachers (DBL, CON and TON) managed to integrate some sustainability competencies such as systems thinking, anticipatory, and strategic in their lesson presentations.

CHAPTER 5: FINDINGS AND RECOMMENDATIONS

5.1 Introduction

The previous chapter presented data relevant to the research question: How are teaching methods and assessment practices used to develop curriculum and sustainability competencies in environmental learning practices? This chapter focuses on Goals 2 to 4 as Goal 1 has already been addressed in Chapter 4.

In discussing the findings, the following sections relate to the key research question informing the study which is in line with the research goals. This is followed by recommendations based on the findings of this study.

5.2 Factors influencing the emergence of sustainability competencies

This section is divided into sub-sections that address Goal 2 of this study, which was to investigate curriculum planning, teaching and assessment practices amongst the four participating teachers.

5.2.1 Curriculum planning and implementation

One of the factors that influences the emergence of the sustainability competencies is the topic of the lesson. The first two teachers (ZOK and DBL) developed lesson plans on the topic 'Population Ecology', the first of two possible topics in the CAPS Life Sciences knowledge strand: Environmental Studies. With this topic, the Life Sciences curriculum aims at helping learners to be more informed and more sensitive to environmental issues and modify their behaviour to lessen their impact on the environment (see Section 4.3.3). This highlights the need for systems thinking competencies for understanding complex socio-ecological interactions within population dynamics.

The first teacher (ZOK) involved her learners in an activity to determine population size by simulating a mark-recapture technique. The lesson activities attempted to address the real-world sustainability problem (impact of an exponential growth of human population on the environment). While the activity focused on understanding the complexity of population growth and its measurement (using a mark-recapture technique), the relationship between population growth and environment was assessed but not taught (see Section 4.2.2.2,

Activities 1 and 2). The teacher developed the lesson activities to address her learners' challenges with calculation, application and interpretation (see Section 4.2.2.2). Even though an important higher order skill – critical thinking through reasoning – was included in the lesson, this was of a scientific and technical nature as it did not develop the socio-ecological higher order system thinking competence needed to understand the complexities of population-environment relationships. The lesson, based on the topic 'population ecology', expected learners to draw on their tacit knowledge when they were asked about the impact of population increase on the environment. Thus, the lesson served to develop foundational knowledge regarding population but did not explicitly lend itself to understanding human-environment relationships (see Section 4.2.4).

The second teacher (DBL) developed lesson activities on the topic 'Impact of human growth on the environment' that reflected the interrelatedness and interdependence of humans and the environment (see Section 4.3.2.1). The lesson activities demonstrated the potential to develop systems thinking competence by highlighting the negative impact of the increase of population size on the environment. This was also supported by the teacher's explanation of carbon footprint where she gave examples of individual, family, community and the country's impact on the environment (see Section 4.3.2.2, Activity 3). The footprint calculation activity raised learners' awareness of their impact on the environment and they compared individual footprints amongst group members. This enabled the development of learners' reflexivity. According to Wiek et al. (2011), normative reflexivity is defined as the ability to specify, compare, apply, reconcile and negotiate in a responsive way (see Section 2.8). This activity would have been good grounding for the further development of reflexivity if 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 destroy the environment as well as how to counteract these actions (see Section 4.3.2.1). Such an extension of this activity would also have addressed the CAPS curriculum interest in the need to suggest solutions to modify learners' behaviour to lessen their impact on the environment.

The other two teachers (CON and TON) developed lesson plans on 'Human impact on the environment', the second topic of CAPS Life Sciences subject knowledge strand: Environmental Studies. In this particular topic, Life Sciences aims to emphasise the interrelatedness and interdependence of human impacts on the environment. This aim lends itself to the development of systems thinking as described in Section 2.11.

The third teacher (CON) and his learners developed the potential for systems thinking by discussing the impact of humans on the environment. Learners were involved in group discussions and presentations on the topic of the greenhouse effect. This offered potential for the development of systems thinking competence as indicated in the lesson activities (see Section 4.4.2.2, Activity 3). Other sustainability competencies that emerged during learners' presentations were anticipatory (predicting the impact the increase of carbon dioxide in the atmosphere would have in the environment) as well as showing strategic competence (introduce solar panels and green technology) to mitigate the effects of greenhouse gases on the environment (see Section 4.4.4).

The same teacher's second lesson addressed a problem of food security. The lesson made use of an article in a local newspaper focusing on food prices. The activity developed critical thinking about the cause and effects of food prices on the availability of food. Activities 2 and 3 gave the learners an opportunity to discuss among themselves the challenge faced by local farmers as well as the country in terms of food security (see Section 4.5.2.2). The lesson activities provided the potential for the development of systems thinking sustainability competence when learners discussed different factors contributing to food security challenges such as human population growth, environmental conditions and agricultural practices (see Section 4.5.2.2). Anticipatory competence emerged when learners predicted the impact of the population increase on the availability of food, citing many challenges that could emerge from this catastrophe (see Section 4.5.2.2.).

The fourth teacher (TON) planned his lesson activity based on the availability and quality of water in a local river. Lesson activities 1 to 4 illustrated the potential to develop systems thinking competence where a textile factory, sewage farm and other human activities were explored in relation to quality and availability of water (see Section 4.6.2.2). Anticipatory competence emerged when the learners anticipated the outbreak of cholera (see Section 4.6.4). The development of strategic competence was enabled by Activity 3 when the teacher explained the strategy taken by the municipality in solving the issue of leaking pipes and asked learners to think of other strategies themselves (see Section 4.6.4.).

The above discussion illustrates that human impact topics lend themselves more strongly to understanding human-environment relationships and therefore are more likely to lead to the emergence of sustainability competencies. The CAPS curriculum gives teachers the

opportunity to expand beyond given content knowledge specified in the document (see Section 2.5), and some of the lessons in this study were able to demonstrate this. This was evident in the lesson where learners explored and wrote a report on three examples of environmental influence in their area (DBL). Further evidence was the research assignment about the Chimanimani permaculture project (CON) and the field trip and report on water quality (TON).

5.2.2 Teaching methods

The teaching methods that influenced sustainability competencies in different ways from all four sampled schools are discussed below. The commonly used method by teachers in this study was question and answer. Teachers explained that they mostly used this method to define concepts, assess learners' prior knowledge and to keep them focused on the lesson. Teachers used this method to actively involve learners to think critically, become more interactive, creative and suggest solutions themselves. This latter use of the method has potential to support reflexive and responsive environmental learning.

Investigative methods were used by two teachers (DBL and TON) in this study. This method was evident when the DBL teacher asked learners to explore how their individual lifestyle choices impact on the environment and TON learners compared quality of water in different sections of the river (see Sections 4.3.2.3 and 4.6.2.3). The evidence of strategic competence developed on the river field trip (as described above) in particular supports the argument of Kostova and Atasoy (2008) (see Section 2.6) that investigative methods can be oriented to agency, capabilities, and social and structural change. Also, this strategic competence contributes towards a responsive approach to teaching. Section 2.9 described responsiveness as learning to cope with profound societal, international and ecological change.

The other teaching methods that were used by teachers were chalk and talk, simulation, use of local examples, group discussion, scenario planning, case study and presentation. This resonates with Loubser (2008) (see Section 2.6) who emphasised that effective teaching of environmental education should move away from teaching and learning based solely on transmission of knowledge. All these methods formed a good base for the development of sustainability competencies such as systems thinking and anticipatory competence. The methods were used by all four teachers to present environmental content knowledge in a

manner that recognises complex system interactions as well as anticipates the effects of human actions on the environment.

In this study, the use of different methods by three teachers (DBL, CON and TON) enabled learners to work with contemporary environmental issues such as food security, impacts of population growth and water issues in their local environment. This was evident when DBL learners investigated their carbon footprint (see Section 4.3.2.2) and CON learners discussed the food insecurity problem in their local environment and deliberated on ways to solve the problem (see Section 4.5.2.2). The TON learners also worked with a local environmental water issue highlighting the need for an educational response by the municipality (see Section 4.6.2.2). These lessons were illustrative of the value of involving learners in real environmental threats and problems and encouraging them to look for solutions (authentic learning) (Lotz-Sisitka & Raven, 2001) (see Section 2.6)).

5.3 The emergence of curriculum competencies in informal and formal assessment in environmental learning

This section addresses Goal 3, which concerns the development and the emergence of curriculum competencies in informal and formal assessment in environmental learning. For each school, curriculum competencies in informal assessment will be discussed, followed by a discussion of the formal assessment tasks.

In the ZOK school informal assessment task, medium and higher order questions dominated (see Table 4.1). The learners performed well in the medium order questions which focused on estimations and calculations. The higher order questions focused on complex thinking where learners were expected to comment on the reliability of the mark-recapture technique and suggest reasons for the difference between estimations and reality. It was at the higher order level that the learners' performance was particularly poor. Lack of exposure to higher order questions during the lesson presentation might be a factor influencing the learners' poor performance in higher order questions in the informal written task. During the lesson presentation, the teacher used interrogative question verbs (why, which and what) when she asked questions. The 2013 examiners' report noted that learners displayed misunderstanding of requirements of action verbs in assessment questions (see Section 2.7). This could be a

reason for learners not achieving in high order questions which used action verbs such as 'suggest a reason'.

In the DBL school, the assessment task required a variety of cognitive skills with medium order competencies dominating. Learners encountered challenges when they had to suggest reasons (higher order) and also showed some difficulty with low order questions that needed definitions of concepts. The reason might be the fact that during the lesson presentation the concepts were written on the board in English and explained in isiZulu, yet in the assessment they had to define these in English (see Section 4.3.2.3). As the questioning and answering was in isiZulu this might also be a limiting factor for learners in developing the curriculum competencies outlined in the CAPS document (see Table 2.2). Learners might know the definition in isiZulu but struggle to translate this to their second language (English).

The first informal assessment task in the CON school, displayed evidence of reflexiveness as learners were able to specify human activities that produce greenhouse gases and compared the current emissions of carbon with future emissions (see Section 4.4.3). This activity enabled learners to think of alternative ways to respond to the greenhouse gases challenge (see Section 4.4.4). In CON school's second assessment task (food security), learners related human exponential growth to food availability as well as its impact on the economy (fuel price increase and food price increase). Learners also specified how environmental occurrences and agricultural sectors had contributed to food insecurity (see Section 4.5.2.2). During the lesson presentations, the teacher worked at a high level as he allowed learners to develop knowledge through group discussion and presentation. He encouraged them to use textbooks to analyse concepts. The lessons supported and succeeded in the development of curriculum competencies including: explain processes, discuss, predict and calculate (see Section 4.4.3 and 4.5.3). Learners presented confidently and their command of English was good. After discussing the food insecurity problem, learners suggested permaculture as a solution (see Section 4.5.3). In the formal task (assignment), low and medium order questions dominated. Learners read and highlighted how Chimanimani responded to the food insecurity problem

The teacher at CON school also made links across the grades when he asked questions on atmosphere and ecology (grade 10 content knowledge) that displayed vertical progression within the subject from simple to complex at higher grade levels (see Section 2.10). This

could be a reason why learners performed well in responding to high order questions in assessment tasks.

The teacher at TON school conducted two assessments. The first one was informal and the second one was formal. The informal task addressed all three cognitive levels, although the medium order questions dominated in the task and learners achieved well at all the levels (see Table 4.6). The reason for high achievement might be the fact that the lesson was an experiential one where learners directly experienced a real water challenge in their area. This might indicate that learners learn better if they are able to relate content knowledge to real-world experience. In this task, few learners displayed difficulty with questions that required them to give reasons

TON school's formal task addressed different aspects around sustainability challenges and learners were expected to suggest reasons and solve environmental problems (see Table 4.2 and 4.7). Learners were tasked to assess and evaluate liquid waste in their area and provide realistic solutions for water quality management (see Table 4.6). In the formal assessment, different aspects of human influence on the environment were assessed such as ozone depletion, greenhouse effect, global warming and over utilisation of natural resources (interconnectedness of related topics). The assessment task developed learners' knowledge of human-environment interactions in a systematic, rather than fragmented, way.

The performance of four learners out of six was excellent (at level five to seven in the informal tasks) (see Section 4.6.2.2, Photograph 19). There may be a connection between learners' successful demonstration of higher order questions in this task and the teacher exposing them to a greater number of higher order questions during the lesson presentation. The TON school (according to the contextual data presented in Section 4.6.1) was advantaged with respect to factors such as availability of resources, class size and language and these factors could also have contributed to the high level of performance at all cognitive levels. This is a possible indicator that local contextual factors influence classroom teaching and learning.

5.4 Integrated approach to developing sustainability competencies in environmental learning processes

This section discusses the fourth goal of this research: To investigate the emergence of an integrated approach to sustainability competencies in environmental learning processes.

With one teacher (ZOK), two sustainability competencies were supported: systems thinking and anticipatory. However, these competencies were not used to build on one another as there was no connection between the population dynamics content knowledge (supporting systems thinking) and the expected knowledge of the impact of population size on the environment (which would have demonstrated anticipatory competence) (see Section 4.2.4). This relates to the concern with the fragmented acquisition of isolated skills or pieces of knowledge (De Kraker et al., 2007) (see Section 2.9).

In the DBL lesson presentation on human impact on the environment, systems thinking and anticipatory competencies were supported (see Section 4.3.4). This was noticed when the teacher explained the concepts required to understand factors influencing population size (systems thinking) and anticipated the impact of an increase in population size on the environment (see Section 4.3.4). The carbon footprint activity opened up the need for reflection on human-environment relationships, but not sufficiently to stimulate learners to make decisions towards modifying their behaviour and lessening their impact on the environment as suggested by Life Sciences environmental knowledge strand 3 (see Section 4.3.2.1).

In the CON first lesson, the competencies that were supported were: systems thinking, anticipatory and strategic competencies. They were integrated as all three are linked (see Section 4.4.4). Through learners' responses, competencies emerged when learners identified greenhouse gases, discussed human activities (systems thinking), anticipated the effects in seventy years to come (anticipatory competence) and decided on alternative ways to building a sustainable future while instilling a sense of responsibility (strategic competence) towards their country South Africa (see Section 4.4.4). These competencies built on one another as they addressed the current situation (where are we now?), the future (where are going?) and action (how do we get there?).

In the CON second lesson focusing on food security, evidence was found of integrated system thinking and anticipatory competencies as learners first analysed the problem (see Section 4.5.4) and then anticipated the impact of food insecurity on local people if the problem was not addressed. In the CON informal assessment tasks, systems thinking and anticipatory competencies were integrated (see Section 4.5.3). Based on learners' work in the formal task (assignment), interpersonal, strategic and normative competencies emerged and were integrated. In this task, learners demonstrated knowledge of the engagement of community members in discussions of how to turn to sustainable food security (interpersonal competence), deliberating on ways to retain water (strategic competence) and taking care of elderly people and orphans through development of permaculture gardens (normative competence) (see Section 4.5.5).

Noticeably, the CON teacher's two lessons supported the development of sustainability competencies (systems thinking, strategic and anticipatory) as these were developed in both lessons presented, thus reinforcing the development of these competencies (see Section 2.4).

The food security activities provided an opportunity for learners to be critical and creative to cope better with the complexity of sustainable development through discussion of sustainable ways of addressing food insecurity (see Photograph 15). Learners in this lesson highlighted a number of aspects contributing to food insecurity and decided on permaculture practice as a solution. Looking more deeply into ethical practices of permaculture could provide a useful springboard for exploring sustainability values and principles in future lessons. Such explorations are central to Wiek's notion of normative reflexivity (see Section 2.8).

In the TON lesson about human impact on water quality and availability, systems thinking (explanation of the impact of society, economy and technology), strategic (revamping smaller pipes into bigger ones) and anticipatory (anticipated diseases like cholera that might occur) competencies were integrated. In the TON school the design of the informal task and the questions supported this integration as was evident from learners' responses (see Table 4.6).

5.5 Summary of the study

This study was conducted as a case study of four schools in the rural town in KwaZulu-Natal Midlands area. The study investigated teaching methods and assessment practices used by

Grade 11 teachers to develop curriculum and sustainability competencies in environmental learning practices. The study employed qualitative methods, specifically questionnaires, lesson observations, stimulated interviews and document analysis. The study found that structural factors in three schools (namely class size, inadequate teaching and learning resources, library and laboratories) were influencing the teaching of environmental learning. Teachers involved in the study had good knowledge of environmental content knowledge and they were qualified and experienced in the subject.

The study also revealed that sustainability competencies the CAPS Life Sciences knowledge strand 3 provides a platform from which all five can be integrated. Systems thinking and anticipatory competencies were supported by all four teachers in their lesson presentation and they were integrated in three of the four schools. The other sustainability competencies that were supported by two schools were strategic competence and one school (CON) demonstrated the emergence of all five competences in an integrated way in the second lesson (food security). However, the interpersonal and normative competencies were not extensively evident, but highlighted by two learners in their research assignments as an important aspect of solving problems.

The study also provided evidence of teachers integrating different methods in their lessons presentation to develop understanding of social and ecological processes. The study found that three teachers (ZOK, DBL and CON) were unable to do fieldwork. This indicates a need for teacher training regarding fieldwork, as this method is one of the CAPS curriculum assessment requirements, particularly with respect to environmental content knowledge. The study found that all three cognitive levels (low, medium, and high) were assessed in all five informal assessment tasks and learners from two schools (ZOK and DBL) displayed a challenge in responding to high order questions that expected them to suggest reasons. Factors such as the use of home language (isiZulu) during lessons presentation, use of low and medium questions during lesson presentations, lack of resources (libraries and laboratories) and use of interrogative verbs (what, how, why) might have negatively influenced learners' performance.

5.6 Recommendations

The study found that the nature of Life Sciences environmental topics and implementation influences the development of curriculum and sustainability competencies. Also, the choice of teaching methods influenced the emergence of particular curriculum and sustainability competencies. The findings also suggested that switching between isiZulu and English, unfamiliarity with action verbs, and the inconsistent use of higher order questions in classroom discussion, informal and formal assessment tasks might have affected success in the development of higher order thinking skills. Finally, the study revealed that environmental learning has the potential to support the development of integrated sustainability competencies.

This study was driven by an interest in environmental content knowledge, teaching and assessment within the South African Fundisa for Change network of environmental educators. It is hoped that the study's illustration of how consideration of curriculum and sustainability competencies can contribute to quality education practices in environmental learning, will be of use in this network.

5.7 Recommendations for further research

There were limitations to the study as it was conducted in only one ward with four teachers. Issues raised in this study are still open for comparison as they were only studied within a small sample of schools.

5.8 Critical reflections

The research process was beneficial to me as well as the participants as it highlighted the strengths and weaknesses of our teaching and assessment practices. From the research and learning process we (participants and I) came to an agreement of setting common assessment tasks together. From this practice a slight improvement in Grade 12 Life Sciences results have been noticed in the two participants' schools that were underperforming. The research study has been most beneficial to me in terms of improving my teaching and assessment practices as it helped me to understand the value of using local environmental issues when teaching

environmental content knowledge. The study highlighted the importance of lesson planning that will enable learners to be actively involved in a lesson.

The stimulated recall interview method was useful as it enabled participants to reflect on their own teaching practices and highlighted the ways they could improve their practices. It also enabled me to learn more about the participants' understanding of the CAPS curriculum as well as the challenges they face when teaching environmental content knowledge. The research would have benefitted from a second stimulated recall interview with the participants, after the assessment tasks, in order to gain insight into their reflections on the impact of their teaching practices on the learner performance (assessment practices). One challenge with these interviews was fitting into one of the participant's busy work schedule. I had to change the method from stimulated recall interview to a questionnaire, which limited the depth and scope of data obtained from this participant. The questionnaire was also useful in giving me a picture of the participants' school context and how these affected their teaching and assessment practices.

There were further challenges I encountered. For example, one lesson observation was disturbed while the lesson was in progress. The teacher had to stop the lesson and let the learners leave to write a Mathematics exam paper that was scheduled by the Department of Education. This illustrates a problem with researching environmental content knowledge which is taught in the third and fourth term when the focus is on examinations.

5.9 Conclusion

The study investigated how teaching methods and assessment practices are used to develop curriculum and sustainability competencies in environmental learning practices. Teaching methods, assessment practices used by teachers involved in this study as well as the curriculum and sustainability competencies developed, were discussed in Chapter 4. The findings were discussed in this chapter (5), followed by the recommendations as well as the further research study recommendations.

The study concluded that, for quality education in South African schools especially in environmental learning, teachers could be supported to develop teaching methods that involve outdoor activities as well as the use of simulation when resources are limited. The

conclusion was that the focus on 'human impact' in the Life Sciences FET CAPS enables the emergence of all five sustainability competencies in an integrated way. The study found that the development of sustainability competencies was supported and they were integrated in three lessons. One of the lessons in the study was able to display the integration of all five competencies as illustrated in Wiek et al.'s model of key sustainability competencies. The study also highlighted the poor performance in higher order questions in two schools; this implies that teachers could be further developed in designing lesson activities that could stimulate critical thinking. The study also used critiques around the notion of competence to review the lessons in order to ensure that a problematic perspective on competency did not limit the analysis of the study. These critiques enabled the application of the lenses of reflexivity, responsiveness and fragmentation to the data.

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APPENDICES

Appendix 1: Sample of a questionnaire

School Profile

1. In which area is your school? e.g. farm, township or rural?

……

2. In which quantile is your school? (fee paying or no fee paying school?)

……..

3. How many teachers do you have in your school?

……

4. How many learners do you have in your school?

……

5. What is the teacher – learner ratio in class?

……

6. What subjects does your school offer in grade 10 -12?

……

7. What is the first language of the majority of learners in your school?

……

8. What is the first language of the majority of teachers?

……

9. What is the language of instruction in your school?

……

10. Briefly describe the infrastructure of the school in terms of buildings, water, electricity and fencing

……

……

11. Can you elaborate on the availability of resources within the school?

……

12. Is the teacher(s) teaching Life Sciences in this school adequately competent to teach it in grade 10 to 12?

……

13. What social factors are you facing in your school?

……

Teacher information

1. How long have you been teaching?

……

2. For how many years have you taught Life Sciences?

……

3. What was your previous pass rate in Life Sciences?

……

4. What are your qualifications?

……

5. What teaching methods do you tend to use in Life Sciences?

……

……

6. What assessment techniques and tools do you use in Life Sciences?

……

……

7. What challenges are you facing in the teaching of environmental content knowledge?

……

……

8. Have you been workshoped on CAPS? If yes, how useful did you find the workshop?.

……

……

9. What supporting materials are available for teaching environmental content?

……

……

10. Are there any comments you would like to make in relation to teaching and assessment of environmental content in Life sciences?

……

……

….

Appendix 2: Sample of a colour coded lesson observation transcript

Category	Colour
Content knowledge	Red
Teaching method	Green
Assessment	Purple

Teacher: These are dominant species; by dominant I mean there are more than any other species. If human beings increase in the world, we look at the impact that would have in the world. By impact we look at the negative impact that might have in the environment. According to your knowledge, we as human beings, how do we depend on environment? Environment being the plants, the soil and other living organisms, (animals). How do we depend on them? What is it that we need from plants?
Learner: We need energy from plants.
Teacher: So we get energy from the sun. What do we call the process whereby plants make their own food?
Teacher: Yes Tizo (pseudoname)
Learner: Photosynthesis
Teacher: It is called photosynthesis, so we are dependent on plants because we get starch from the plants. So you know from your knowledge of food chain that sometimes we do not get energy directly from plants, sometimes its indirectly whereby we eat animals that eat grass in that way that is indirectly e.g. cow. So what we are based on today, we are looking at the human population size on how it affects the environment. So it has been proven that population human population is increasing gradually. If it was started with two people, Adam and Eve in the world, then the human population started to grow and grow. Every year the survey or every five years the survey that is done, we find that human population is shooting up, but as it increases, how does it affect the environment? Tell me how human population size affects the environment? Think of the simplest form at your home, you started being only two members, then being your cousins come to live with you, think about the space, how will you be affected?
Learner: The more the population increases, there will be a shortage of space; plants too will be affected through deforestation where trees which photosynthesizes, isn't Miss?
Teacher: Yes
Learner: Trees need carbon dioxide, then the oxygen that is given off by trees as a byproduct that means we will be running short of O_2 that we need.
Teacher: So she talked about increasing of human population will lead to the process of deforestation. So it will have an impact around us. For example, the increase of human, it's obvious it will need more space that will mean the area that had trees. Remember that trees
Don't just only photosynthesize to provide human with O_2, they also provide shelter for other animals. You know there are animals that live full time in the forest, like what? Which animal live full time in the forest?
Learner: Baboon
Teacher: Baboon, exactly. Listen springboks live under the trees, so trees do not supply oxygen to human beings, they are also useful to other animals. When the human population grows, more space will be needed for shelter. The Government sat down and realized that human population has grown, so he needs to build more RDP houses. Trees were destroyed even if it's two or three that were providing oxygen, supporting even the 5 ants, now they have destroyed the homes of other animals. When trees or plantations are destroyed that is the process of deforestation. So we say deforestation is the removal of trees or forest. We said photosynthesis is when plants use CO_2 , water and light make their own food, so this is how we are dependent. If deforestation takes place, we are minimizing plants and limiting the amount of O_2 that is in the air. In terms of CO_2, How is deforestation going to affect the level of CO_2 in the air? By removing trees, how will it affect the level of CO_2 ? Is it going to increase or decrease? What will happen if it continues to happen? Yes, Siza (pseudoname)
Learner: It will increase
Teacher: Why will it increase?
Learner: It because trees that uses it has been destroyed and CO_2 that human beings exhale will accumulate in the air and no trees to absorb it.
Teacher: Exactly the level of CO_2 will rise, because trees that were supposed to absorb it have been destroyed and there are few left because others have been cut down. So reflect to your grade 10 content that the rise of CO_2 lead to ozone layer, greenhouse gases and thee rise of temperatures has an effect on global warming. And what effect global warming will have in the environment. So besides deforestation, what are other impacts the rise of human population will have on the environment?
Learner: Unemployment rate will increase.
Teacher: Do you mean people who will be without jobs?
Learner: Yes, which will lead to an increase of crime rates and the spread of diseases.
Teacher: So what, if the criminals increases, how will it affect the environment?
If we have too many criminals how will it affect the environment?
Learner: When the criminals kill people, those people need to be buried, that means plants will be destroyed when tombs are dug.
Teacher: So I can take that answer because whenever you think of any impact, you must link it by stating how it affects the environment. Let's say if the population increases the industries will fail to employ more people because people will be more than job opportunities, which will lead to high unemployment rate which in turn will give rise to high crime rate. Crime rate will lead to an increase of death rate, so more space will be needed for burial which destroys environment by decreasing biodiversity of plants and animals. That is why government is proposing that people must be buried standing, have you heard of that?
Learners: (chorus) Yes/ No!
Teacher: Why?
Learner: Because there is no space and plants are destroyed.
Teacher: Yes, that has already started; Government has noticed that people are increasing in numbers drastically, so you will end up being buried on top of your grandfather. Ok what is other impact?

Learner: Soil erosion
Teacher: what a big concept? What do you mean?
Learner: That means Miss, the removal of soil.
Teacher: what causes it?
Learner: Even in that Miss, 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.
Teacher: Exactly, even when they are building those houses, they use tractors that degrade the soil, killing small insects. Once it has degraded the environment, no plants will ever grow there. Because the more you walk on the same path, the soil is destroyed as well as soil nutrients. Even though I have never gone to Hlathikhulu but I think it's a place that has large space where one can plant vegetables.
Learners: Yes (chorus)
Teacher: Let's say you are two in your family, and then all your cousins from your granny that you don't know come and stay with you. Due to the fact that you have increased you will need to build another house within the premises. Each one builds his or her house in the garden. What are you doing, you are limiting the space and destroying the environment. You will experience the shortage of food and space. Then can we try to look at the concept called ecological footprint. Turn to page 319 in your life sciences books and any one can read for us.
Learner: reads
Teacher: Ok we are looking at the term ecological footprint leading to the environment destruction. If we say ecological footprint we mean are talking about the area that an individual (you alone) or your family or the whole country that it uses to supply demands of your lifestyle. For example like the one I made earlier on about your where you were 5 in a family. You have a garden, where you are planting mealis, beans and other vegetables. By the time the number increases, more space will be needed than the one you had for more shelters to build extra rooms, there will be a shortage of beds and food. The demand for food will be high so, the garden needs to be extended. If you were eating one loaf of bread that means you will need two loaves of bread in order to meet the demand for the population growth. What we say ecological footprint is an area that you use to meet the demands of your life style. If the population grows that means even the demands will increase as well as the space. So that is ecological footprint, even if you are alone, you do have an ecological footprint. The activities that you do in the space you have in the environment are your lifestyles demands. If one person joins you in your space, space need to increase, so everything will increase, economy and you're the footprint for both of you. That is why we say ecological footprint is an area of an individual or family or the whole country that particular country uses to meet or support individuals living in that country. Ecological footprint is divided into two, there is light and heavy ecological footprints. Light footprint means a small to moderate impact on the environment even the number increases but the environment can support you and the heavy footprint indicates a high degree of environmental degradation. Environment now get affected. For example if you are 3 members in your family, everyone has his or her own bed. If one person joins you increase, isn't? But in terms of space you have not affected because he or she will share a bed with one of you. Another person comes now you are 5 still there is space in two beds. Are you affected according to space Yes or No?
Learners: (chorus) No
Teacher: Because he or she can share a bed with the other one. If another group of people come then you end up being ten by the end of the year, your impact now will be felt by the space around you because you are too many, environment will be affected.
(Writes definition of the two types of footprints on the board) It will depend on whether the country is affected or not. If people from outside the country immigrate in another country, what happens in the family will happen in the country. The more population increases there will be a shortage of space, shortage of food,, increase crime rate all these will affect the environment. As we are still on ecological footprint, by Light has less impact and heavy has larger impact (high degrees of impact). In your exercise books, not exercise books, textbooks, there is a short activity for you guys to determine how you as an individual destroy the environment. Are you in light or heavy? Please turn to page 318 and the handout on the next page. If you look at the table, it has some questionnaires there. How are you going to do this, turn your chairs to the people behind you and for a group of 4. There are questions there, you determine an individual footprint and add with the other members' footprint in your group. I want to see which group destroy the environment. Activity page 319. First question says: How much water do you use, 2. what kind of food do you eat? 3. How do you shop? 4. Where do you live? 5. How much electricity do you use? 6. How do you get to school? 7. How much paper do you use? 8. How much rubbish do you throw away? If there is a question that you don't understand ask your neighbor. At the end, you have the total score of 100, what you will do you will add all the numbers and divide by the 100 then it will be the group's impact. We want to see how much space you used that will be your ecological foot print. Are you light or heavy person.
(Teacher assist groups with calculations) she draws 7 columns on the board to write results. Now give me the scores.
Learners: Group 1= 4.58 group 2= 4.56 group 3= 2.88
group 4 = 4.21
Group 5= 3.44 group 6= 5.90 group 7 = 6.18
Teacher: Which group has the heaviest footprint?
Learners: (chorus) group 7
Teacher: Which group has the lightest?
Learners: group 3
Teacher: From your understanding, according to what you have done and see, you think which country has the affect the environment the most between the underdeveloped and developed countries?. If we are talking about developed country we talk

about country like America. They have the best technology, children at the age of 13, 14 by the time they reach 18, they have driving licenses and parents have bought them cars. There are best hospitals and underdeveloped country they lack resources, poor infrastructure. If you think which one destroys the environment between them?
Learner: Developed one
Teacher: If the developed one, Why?
Learner: They waste a lot
Teacher: What does it waste?
Learner: They have lot of cars as young children have cars too, which releases CO2 into the atmosphere, which causes global warming.
Teacher: Ok is there anyone who thinks it's the underdeveloped? Ok actually yes. According to population size, which one do you think has a high rate of population? Think about the poor and the rich family. Which one used to have more members?
Learner: Underdeveloped, more population due to poverty, they give birth so that they can get grant.
Teacher: What do others say?
Learner: Developed because those from underdeveloped will migrate to developed one.
Teacher: Let's say there is a race if we talk about race I mean blacks, whites and Indians. Which one is being perceived as rich one?
Learners: (Chorus) whites
Teacher: They have access to resources the one who is poor cannot afford.
How can you as DBL school do to decrease the impact? Go home, think and come back tomorrow on how you as an individual suggest the school can do to reduce ecological footprint. What the school can do to reduce learner's footprint on the environment?

Appendix 3: Sample of colour coded stimulated interview transcript

Category	Colour
Content knowledge	Red
Teaching method	Green
Assessment	Purple

Researcher: Good afternoon Miss

T2: Good afternoon

Researcher: Firstly I just want to play the first lesson that I observed. So on this one you say now your lesson was based on the human impact- population size on the environment. I just want to find out what was your intention? What is it that you wanted the learners to know?

T2: Ok, I think the main intention was for learners to know everything that the human do in one way or another it does affect the environment so we have to preserve the environment. So in order to preserve it we have to know what the human beings do to destroy it so that we can know how to counter act it. To save environment because it is important to us.

Researcher: Thank you very much for that answer, I am going to play another video clips. So when we look at this one, we can see that teaching was mostly in Isizulu, I just want to find out what socio-cultural factors shaped the teaching and learning that took place in the lesson? How did they contribute to teaching and learning?

T2: The learners that I teach, their first language are Isizulu, even if they communicate at homes. Their social environment they are growing up into is Isizulu. So it is important for me that when teaching I have to code switch to Isizulu so that they will understand the concepts better. Because language has a role in teaching so that learners will understand. I do use English but I have to code switch to the language that they understand to make things easier for them. And also even if it comes to environment, their experiences that they encounter involve the language they are used to.So their background, if you see their historical background, they are more exposed to their home language than English. I do use English but there are concepts that I need to explain in Isizulu.

Reseacher: Thank you so much for answering that question. So the other thing I just want to find out from you. I just wanted to find out the method you used, because mostly you were using question and answer method and also chalk and talk. Why did you choose those methods? Particularly in this lesson.

T2: So, firstly the chalk method it helps learners in terms of spelling because a learner can know a lot about environment but he cannot be good in spelling. If you have written down the word she will know how to spell it and also understanding it. He will never forget it. When it comes to question and answer by the time you ask a learner a question, you stimulate his brain so that he can think. So that he will see that what you teach is not something far from his environment. So it helps a lot that is why I chose it so that when I teach, I ask a question in between so that a learner's brain will focus on what we are doing. We are not talking about something they he does not know or something happened in another environment, but we are learning about something that happens in his environment.

Researcher: I just want to find out also regarding your teaching and assessment, is there anything that your learners are struggling with in terms of curriculum competencies? What are those curriculum competencies your learners are struggling with?

T2: Em, what I can say our learners especially the ones that I teach, curriculum demands that learners be exposed to libraries and other resources that will help them to understand curriculum better. They rely mostly on the textbook, they are not exposed to technology yet knowledge is all over now, but they can't access it.

They struggle a lot in accessing knowledge as they have only the textbook to refer to.

Researcher: How do you help the learners to develop those curriculum competencies that they are lacking?

T2: Most of the time I try to look for more resources, consult different textbooks, or if I happen to get a DVD that talks about environmental part. There are some DVDs that talks about animals and human survival and so forth. So it becomes my duty to get some DVDs that can watch. Then they relate it to what they have learnt in the classroom. I also use some other textbook they might explain much better the same concept.

Researcher: What was your aim of carbon footprint activity specifically when learners are asked to start calculating their carbon footprint before comparing it with their group mates?

T2: The aim of the lesson was that the learner as individual should know how he contribute to carbon because when we talk about human impact, he should understand that he also contribute carbon emission. By calculating theirs individually, I wanted them to realize how each of them negatively impact the environment. My aim was to let each one of them to take full responsibility of his or her actions and see that the future of the environmental resources lies upon each of them to save them. So they will realize that to save the environment, they have to do something. By comparing with his carbon footprint with his group mates, enabled them to see how much damage they cause on the environment, then they can decide on the action to take to reduce their impact on the environment.

Researcher: When observing this video of your lesson presentation, what else can you do to improve the quality of teaching and learning of environmental content knowledge?

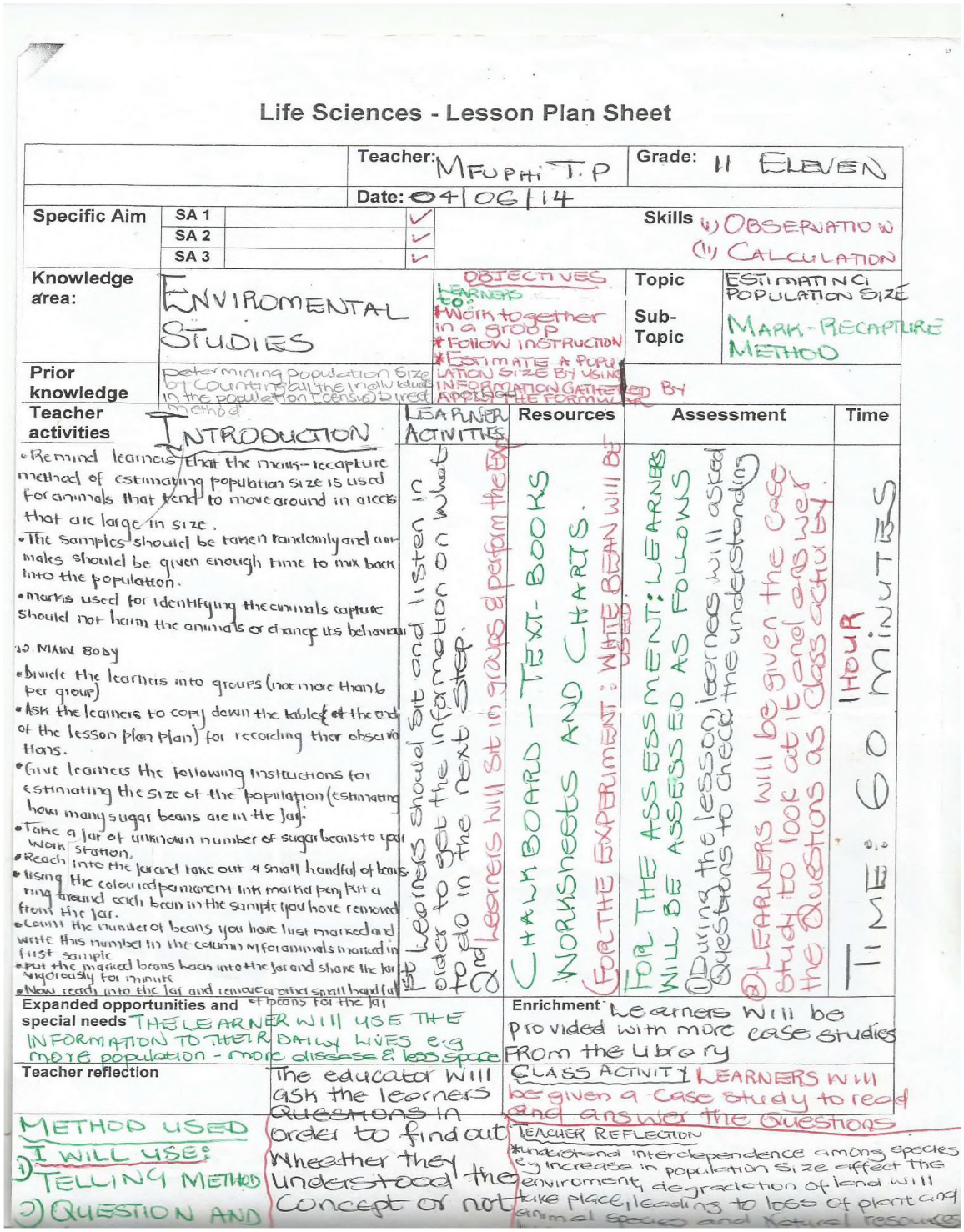
T2: I will probably, environment is nature so it is very hard to explain it right through in theory. So I will probably plan my lessons to be an outdoor lesson where the environment is. So learners will not end up with theory, as it is all about what they know. By taking them out for excursion will help learners to understand better all what they have learnt in the classroom? I will improve it by not concentrating only to textbooks but to take excursions to let them see and learn more about environmental aspects they are dealing with in that time.

Researcher: Are there any challenges that you encounter when teaching environmental content knowledge, since it is new and most of us have not been trained about it during our teacher-training?

T2: Yes, Challenges link to your previous question, all the information I have as a teacher I get it from the textbook. So the learners also rely on the textbook. The challenge of environmental content knowledge is that there should be a part of observation, because it is practical. It can be seen, the challenge is we rely on theory that we get from textbooks. It seems that a teacher and a learner should be exposed to all the environmental aspects that are in the curriculum. Teachers and learners will understand environmental content knowledge much better if it is a hands-on lesson.

APPENDIX 4: Lesson plans

Appendix 4.1: ZOK Lesson Plan



Life Sciences - Lesson Plan Sheet

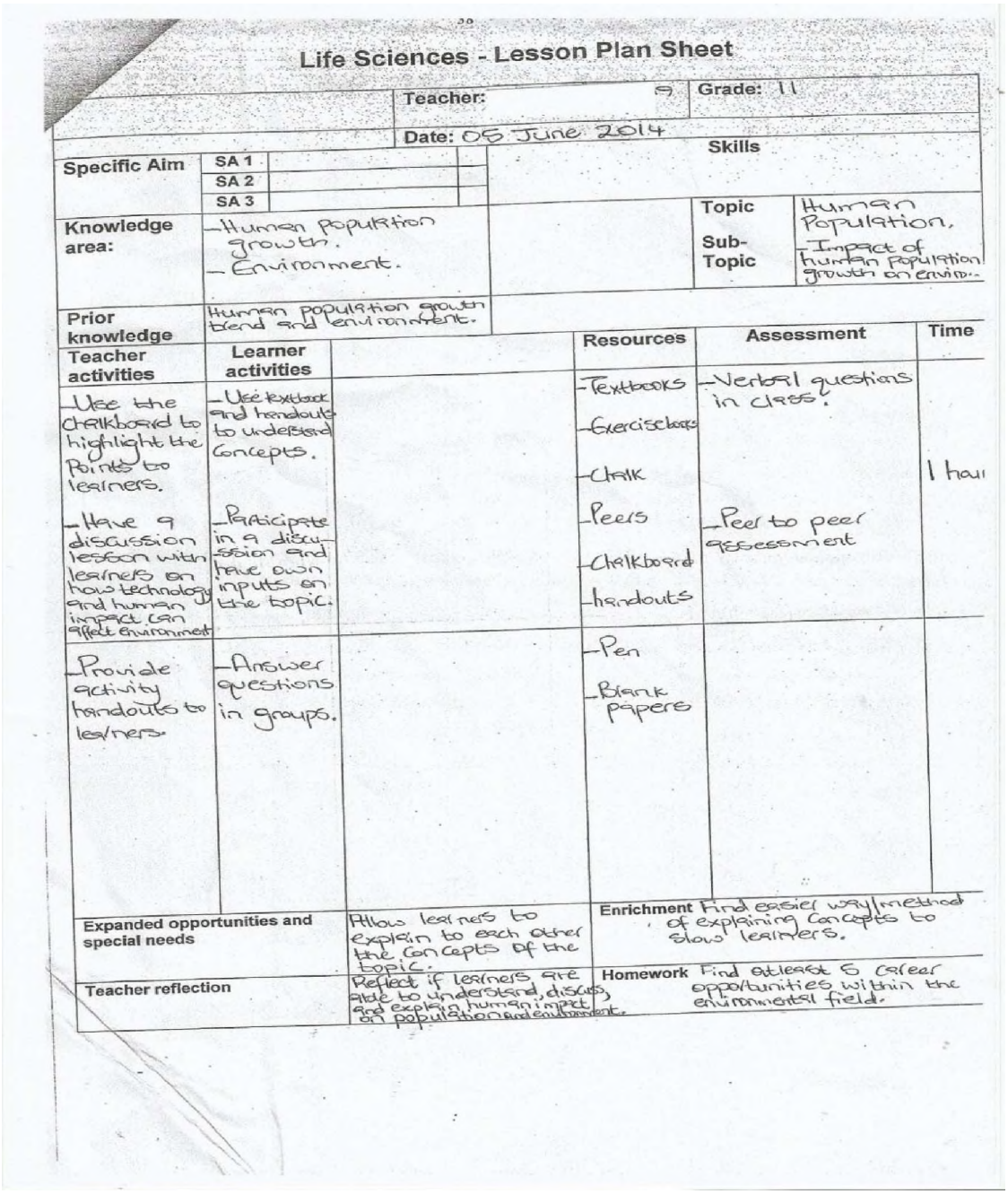
	Teacher: MFUPHI T.P	Grade: 11 ELEVEN	
	Date: 04/06/14		
Specific Aim	SA 1 ✓	Skills i) OBSERVATION ii) CALCULATION	
	SA 2 ✓		
	SA 3 ✓		
Knowledge area:	ENVIROMENTAL STUDIES	OBJECTIVES LEARNERS TO: *Work together in a group *Follow instruction *Estimate a population size by using information gathered by applying the formula	Topic: ESTIMATING POPULATION SIZE
			Sub-Topic: MARK-RECAPTURE METHOD
Prior knowledge	determining population size by counting all the individuals in the population (census) Direct method		

Teacher activities	Learner Activities	Resources	Assessment	Time
INTRODUCTION • Remind learners that the mark-recapture method of estimating population size is used for animals that tend to move around in areas that are large in size. • The samples should be taken randomly and animals should be given enough time to mix back into the population. • Marks used for identifying the animals capture should not harm the animals or change its behaviour. 2) MAIN BODY • Divide the learners into groups (not more than 6 per group) • Ask the learners to copy down the table(s) of the activity of the lesson plan plan) for recording their observations. • Give learners the following instructions for estimating the size of the population (estimating how many sugar beans are in the jar): • Take a jar of unknown number of sugar beans to your work station. • Reach into the jar and take out a small handful of beans • Using the coloured permanent ink marker pen, put a ring around each bean in the sample you have removed from the jar. • Count the number of beans you have just marked and write this number in the column M for animals marked in first sample • Put the marked beans back into the jar and shake the jar vigorously for minute • Now reach into the jar and remove another small handful of beans for the jar	Learners should sit and listen in order to get the information on what to do in the next step. Learners will sit in groups & perform the Exp	CHALKBOARD - TEXT-BOOKS WORKSheets AND CHARTS. (FOR THE EXPERIMENT: WHITE BEAN WILL BE USED	FOR THE ASSESSMENT: LEARNERS WILL BE ASSESSED AS FOLLOWS ①During the lesson, learners will asked Questions to check the understanding ②LEARNERS will be given the case study to look at it and answer the Questions as class activity.	1HOUR TIME: 60 MINUTES
Expanded opportunities and special needs: THE LEARNER WILL USE THE INFORMATION TO THEIR DAILY LIVES e.g more population - more disease & less space		Enrichment: Learners will be provided with more case studies from the Library		
Teacher reflection: The educator will ask the learners Questions in order to find out Wheather they understood the Concept or not		CLASS ACTIVITY: LEARNERS will be given a case study to read and answer the Questions		

METHOD USED
I WILL USE:
1) TELLING METHOD
2) QUESTION AND

TEACHER REFLECTION
*Understand interdependence among species e.g increase in population size effect the environment, degradation of land will take place, leading to loss of plant and animal species and Natural resources

Appendix 4.2: DBL Lesson Plan

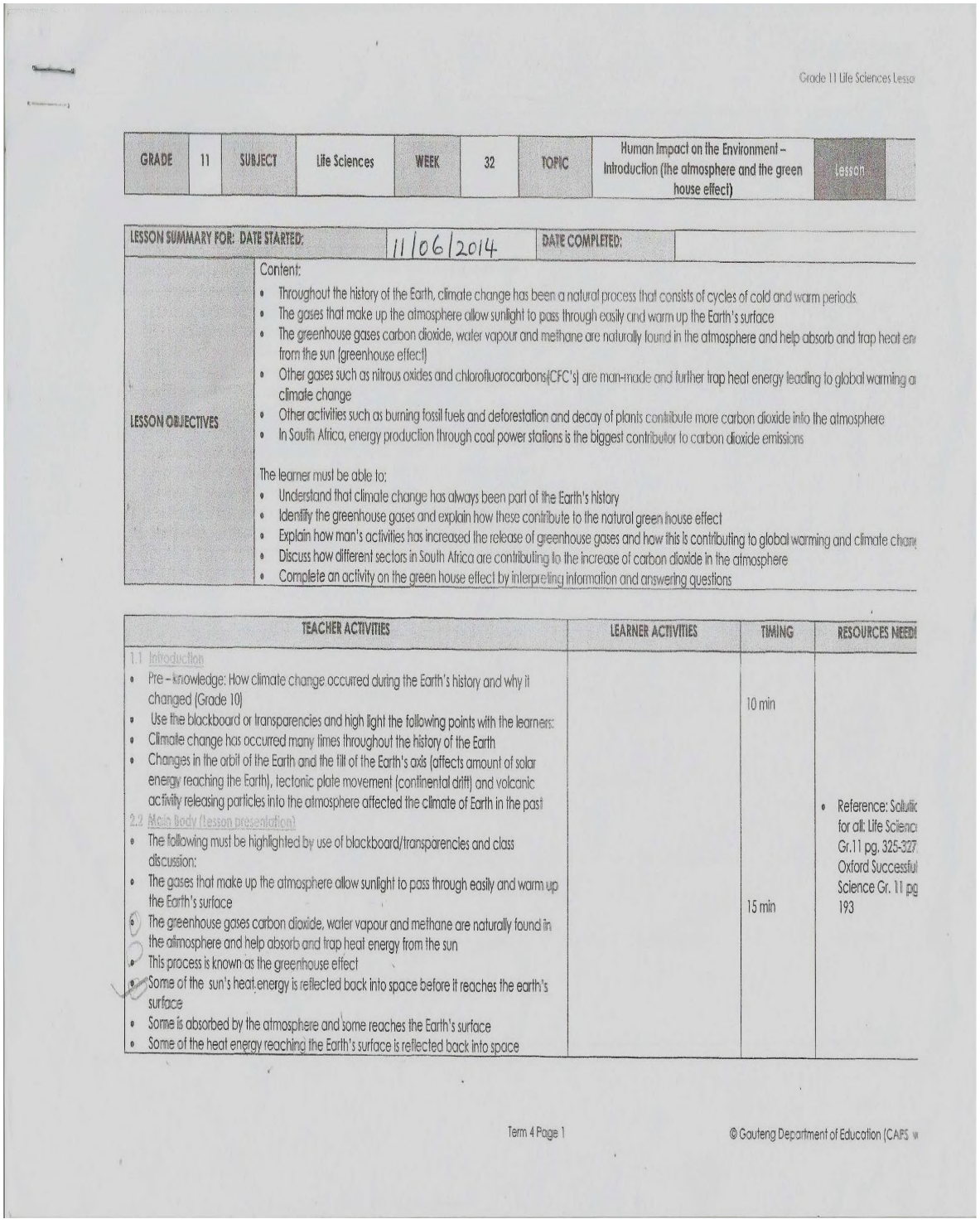


Life Sciences - Lesson Plan Sheet

	Teacher:		Grade: 11
	Date: 05 June 2014		
Specific Aim	SA 1	Skills	
	SA 2		
	SA 3		
Knowledge area:	-Human population growth. -Environment.	Topic	Human Population.
		Sub-Topic	-Impact of human population growth on enviro..
Prior knowledge	Human population growth trend and environment.		

Teacher activities	Learner activities		Resources	Assessment	Time
-Use the chalkboard to highlight the points to learners. -Have a discussion lesson with learners on how technology and human impact can affect environment	-Use textbook and handouts to understand concepts. -Participate in a discussion and have own inputs on the topic.		-Textbooks -Exercisebooks -Chalk -Peers -Chalkboard -handouts	-Verbal questions in class. -Peer to peer assessment	1 hou
-Provide activity handouts to learners.	-Answer questions in groups.		-Pen -Blank papers		
Expanded opportunities and special needs		Allow learners to explain to each other the concepts of the topic.	Enrichment	Find easier way/method of explaining concepts to slow learners.	
Teacher reflection		Reflect if learners are able to understand, discuss and explain human impact on population and environment.	Homework	Find atleast 5 career opportunities within the environmental field.	

Appendix 4.3: CON Lesson Plan 1



GRADE	11	SUBJECT	Life Sciences	WEEK	32	TOPIC	Human Impact on the Environment – Introduction (the atmosphere and the green house effect)	Lesson	

LESSON SUMMARY FOR: DATE STARTED:	11/06/2014	DATE COMPLETED:	

LESSON OBJECTIVES

Content:

- Throughout the history of the Earth, climate change has been a natural process that consists of cycles of cold and warm periods.
- The gases that make up the atmosphere allow sunlight to pass through easily and warm up the Earth's surface
- The greenhouse gases carbon dioxide, water vapour and methane are naturally found in the atmosphere and help absorb and trap heat en from the sun (greenhouse effect)
- Other gases such as nitrous oxides and chlorofluorocarbons(CFC's) are man-made and further trap heat energy leading to global warming a climate change
- Other activities such as burning fossil fuels and deforestation and decay of plants contribute more carbon dioxide into the atmosphere
- In South Africa, energy production through coal power stations is the biggest contributor to carbon dioxide emissions

The learner must be able to:

- Understand that climate change has always been part of the Earth's history
- Identify the greenhouse gases and explain how these contribute to the natural green house effect
- Explain how man's activities has increased the release of greenhouse gases and how this is contributing to global warming and climate chan
- Discuss how different sectors in South Africa are contributing to the increase of carbon dioxide in the atmosphere
- Complete an activity on the green house effect by interpreting information and answering questions

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEED
1.1 Introduction • Pre – knowledge: How climate change occurred during the Earth's history and why it changed (Grade 10) • Use the blackboard or transparencies and high light the following points with the learners: • Climate change has occurred many times throughout the history of the Earth • Changes in the orbit of the Earth and the tilt of the Earth's axis (affects amount of solar energy reaching the Earth), tectonic plate movement (continental drift) and volcanic activity releasing particles into the atmosphere affected the climate of Earth in the past		10 min	• Reference: Solutio for all: Life Scienc Gr.11 pg. 325-327. Oxford Successful Science Gr. 11 pg 193
2.2 Main Body (lesson presentation) • The following must be highlighted by use of blackboard/transparencies and class discussion: • The gases that make up the atmosphere allow sunlight to pass through easily and warm up the Earth's surface • The greenhouse gases carbon dioxide, water vapour and methane are naturally found in the atmosphere and help absorb and trap heat energy from the sun • This process is known as the greenhouse effect • Some of the sun's heat energy is reflected back into space before it reaches the earth's surface • Some is absorbed by the atmosphere and some reaches the Earth's surface • Some of the heat energy reaching the Earth's surface is reflected back into space		15 min	

Appendix 4.4: CON Lesson Plan 2

Subject: Life Sciences **Grade:** 11

Topic: Population Ecology- Food security **Date planned:** 15/09/14

Specific Aim: 1, 2 and 3

Teacher Activities	Learner Activities	Resources	Assessment	Time
Teacher introduces the lesson by consolidating previous work done on the previous lesson on human impact on the environment- greenhouse gases	Listening and writing down definition.	Life Sciences Text book grade 11		5 min.
Introduces new content- Food security by defining the term: Food Security. Asking questions. **Mention factors that affect food security.** - Exponential growth of human impact - Droughts and floods(climate change - Poor farming practices - Monoculture, pest control, loss of topsoil and need for fertilizers	Writing notes., answering questions Reading newspaper article **Village Talk-** local newspaper 'Drought threat to food industry' Discuss how poverty and food security linked	Newspaper article		20 min.
	Discuss how small scale agriculture can increase food security. Mention main agricultural products produced locally.	Focus Geography book Grade 12 pg. 265		20 min.
Genetically modified foods Loss of wild varieties - Impact on gene pool	South Africa' top ten agricultural products by value. Pg. 259 geography book.		Classwork	15 min.
Teacher Reflection:		**Homework:** Write a few paragraphs explaining why food insecurity in South Africa so often occurs in the former homelands. End by suggesting one possible long-term remedy.		
Enrichment: Contribution of agriculture to the South African economy.				

Appendix 4.5 TON Lesson plan 1

Life Sciences - Lesson Plan Sheet

		Teacher:	Grade: 11	
		Date: 3 SEPTEMBER		
Specific Aim	SA 1	Knowledge -	Skills: observation, recording application	
	SA 2	investigation		
	SA 3			
Knowledge area:	Environmental Studies.		Topic: Water quality	
			Sub-Topic: Mooi River (Prac demonstration observation lesson)	
Prior knowledge	Gr 10			

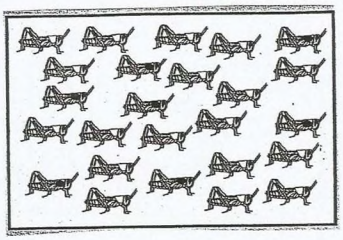
Teacher activities	Learner activities	Resources	Assessment	Time
Study 8km of Mooi River from Textiles Weir to Helen's Bridge	observe how the water quality gets poorer from the weir. Identify all the problem areas causing the degredation of the water quality. (- Mention sewage leakage Exotic trees, litter from the Dump Thermo pollution, sewage farm)	- E Coli test results - sewage farm visit.	Worksheet on observations both the problems and solutions.	1 hour
Follow up. Complete worksheet then have a class discussion about the rest of South Africa - refer to Text books and DVD.				

Expanded opportunities and special needs	Enrichment: Further study of Weston's Water management and quality
Teacher reflection: learners enjoyed going out of the class studying a local river's problems	Homework: Complete W/S.

Appendix 5.1 ZOK Assessment Task 1

LIFE SCIENCES GRADE 11
CLASS ACTIVITY **04/06/14**
Estimate population size by Mark-Recapture

1. In an investigation to determine the number of grasshopper in a field, 14 grasshoppers were caught and a spot of blue paint was applied to the shield of each. The grasshoppers were then released into the field.
   Two weeks later a sample of 25 grasshoppers were re-captured from the same field. The drawing shows the grasshoppers that were re-captured.



1.1 Estimate the total number of grasshoppers in the field. Show all working. (5) Medium
1.2 Suggest a reason why a estimated size of the population may differ from the real population size. (2) High
1.3 State TWO ways in which the reliability of this method can be improved. (2) Low

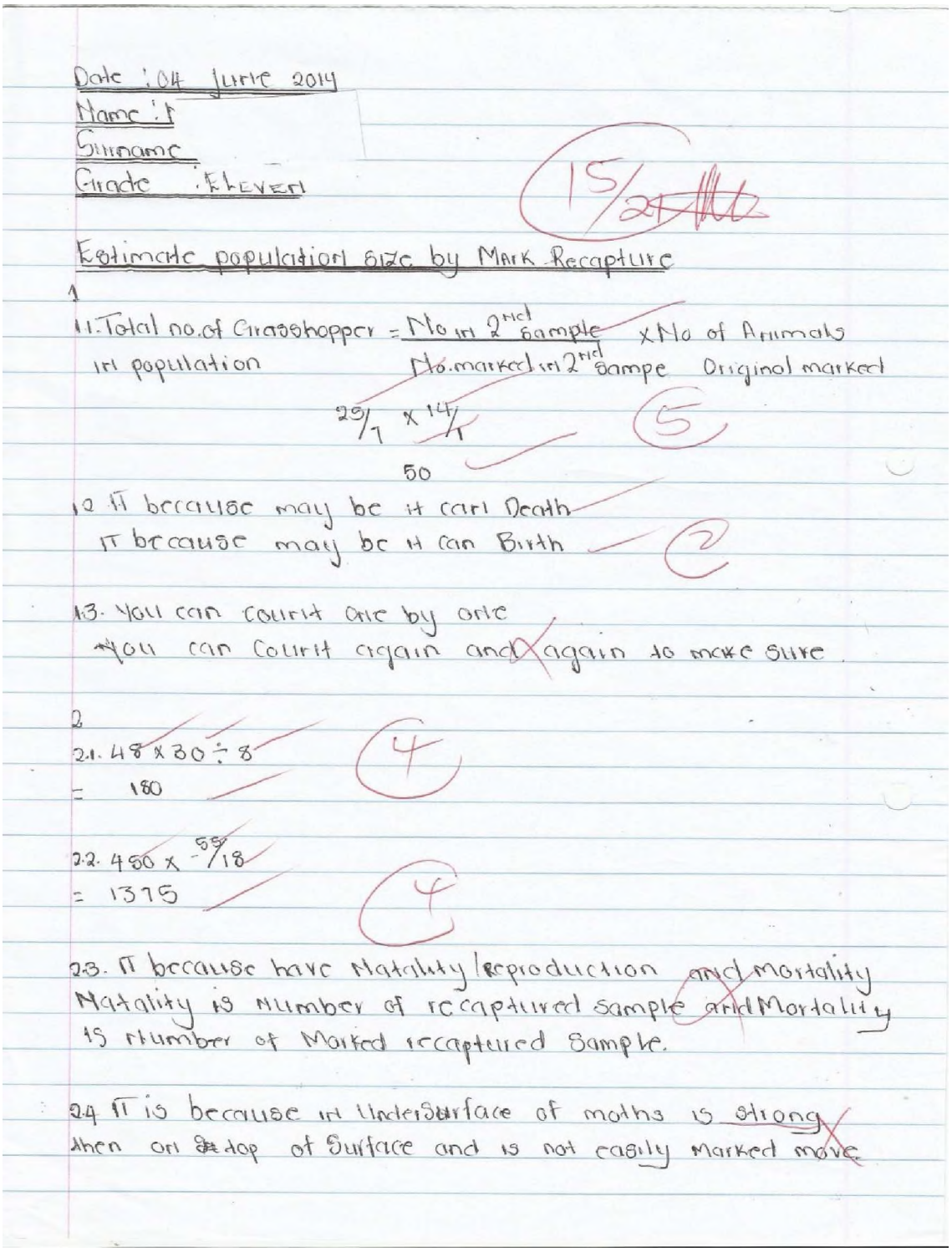
2. A group of students in an industrial area were given a school project which required them to

Determine the population size of two species of moths (A and B). Their results are indicated in the following table.

Species	April 1999	May 1999	
	Number marked and released	Number in captured sample	Number marked in re-captured sample
A	25	402	10
B	30	48	8

2.1 Estimate the size of species B. Show al working. (4) Medium
2.2 Estimate the total number of moths in the area. Show all working. (4) Medium
2.3 Suggest why there is a difference in the numbers between species A and species B. (2) High
2.4 Why did the student mark the moths on the undersurface of the animals? (2) High
Suggest/give a reason
[21]

Appendix 5.2: Sample of ZOK Learner's work



Date : 04 June 2014
Name :
Surname
Grade : ELEVEN

15/21

Estimate population size by Mark Recapture

1

1.1. Total no. of Grasshopper in population = No in 2nd sample / No. marked in 2nd sampe × No of Animals Original marked

29/1 × 14/1 / 50 (5)

1.2 π because may be it can Death
π because may be it can Birth (2)

1.3. You can count one by one
You can count again and again to make sure.

2

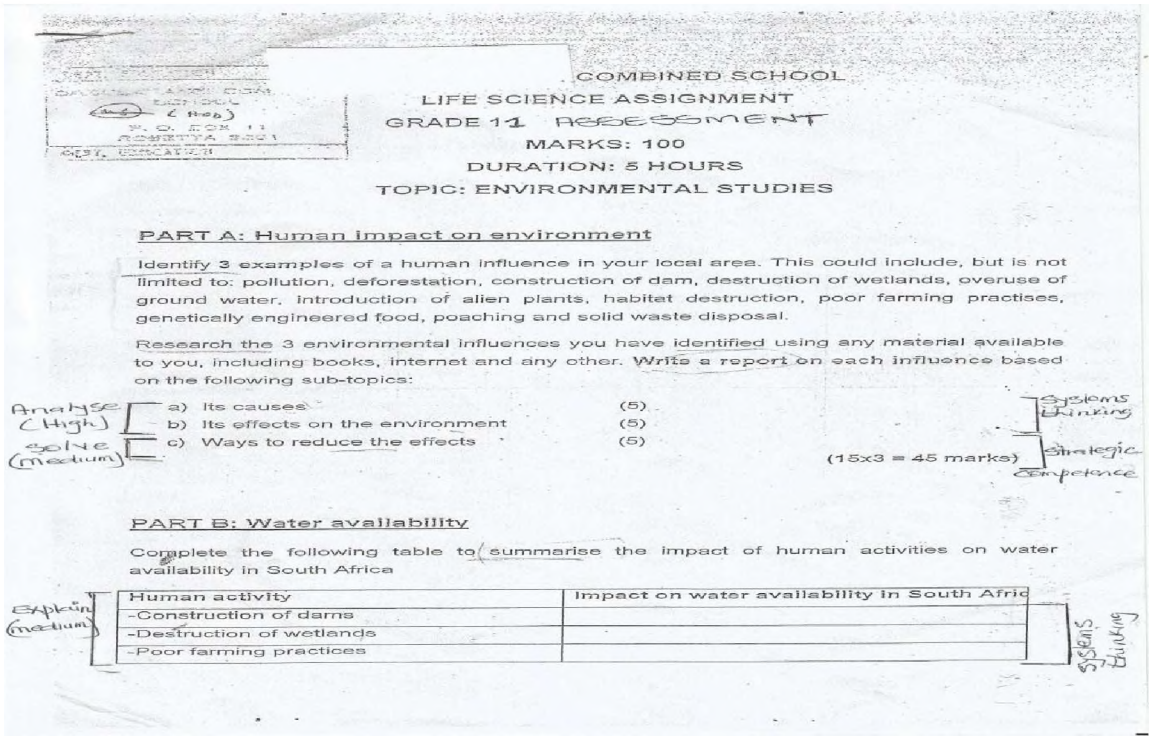
2.1. 48 × 30 ÷ 8
= 180 (4)

2.2. 450 × 55/18
= 1375 (4)

2.3. π because have Natality/reproduction and Mortality
Natality is Number of recaptured sample and Mortality is number of Marked recaptured Sample.

2.4 π is because in Under Surface of moths is strong then on top of Surface and is not easily marked move.

Appendix 5.3: DBL Assessment Task



COMBINED SCHOOL
LIFE SCIENCE ASSIGNMENT
GRADE 11 ASSESSMENT
MARKS: 100
DURATION: 5 HOURS
TOPIC: ENVIRONMENTAL STUDIES

PART A: Human impact on environment

Identify 3 examples of a human influence in your local area. This could include, but is not limited to: pollution, deforestation, construction of dam, destruction of wetlands, overuse of ground water, introduction of alien plants, habitat destruction, poor farming practises, genetically engineered food, poaching and solid waste disposal.

Research the 3 environmental influences you have identified using any material available to you, including books, internet and any other. Write a report on each influence based on the following sub-topics:

Analyse (High) / solve (medium)

a) Its causes (5)
b) Its effects on the environment (5)
c) Ways to reduce the effects (5)

(15x3 = 45 marks)

Systems thinking / Strategic competence

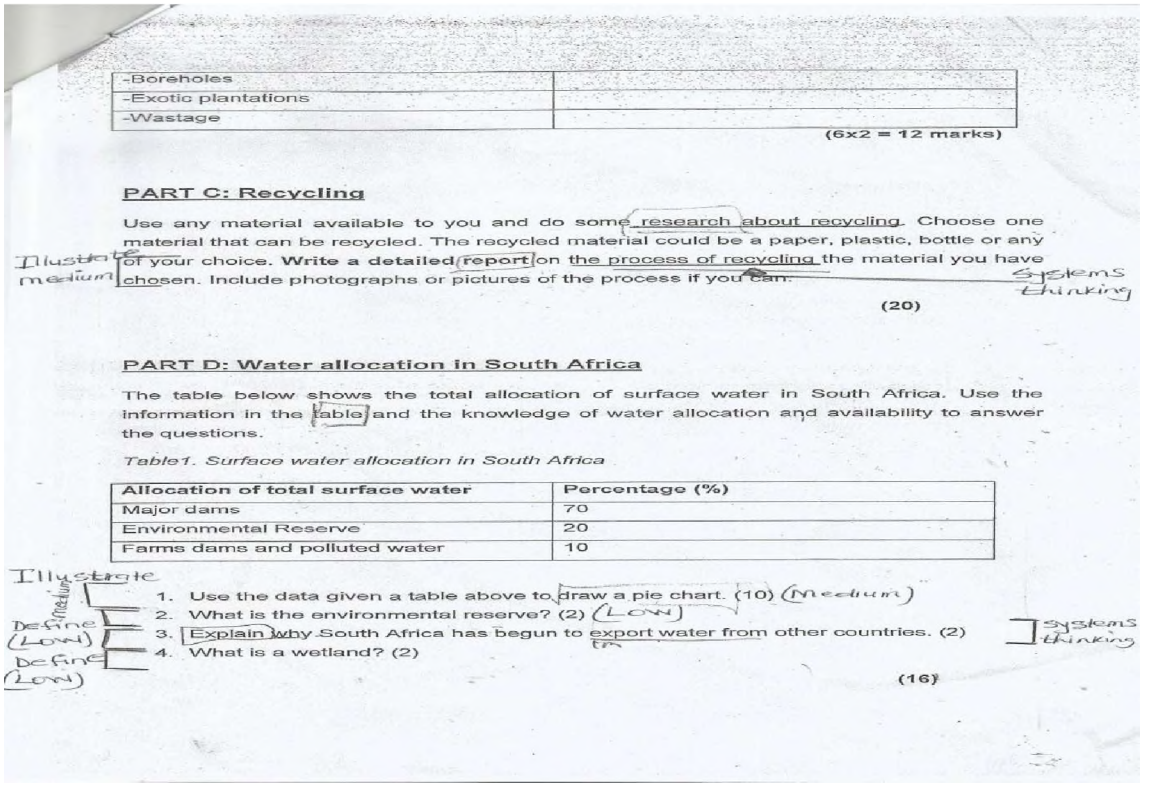
PART B: Water availability

Complete the following table to summarise the impact of human activities on water availability in South Africa

Explain (medium)

Human activity	Impact on water availability in South Afric
-Construction of dams	
-Destruction of wetlands	
-Poor farming practices	

Systems thinking



-Boreholes	
-Exotic plantations	
-Wastage	

(6x2 = 12 marks)

PART C: Recycling

Illustrate medium

Use any material available to you and do some research about recycling. Choose one material that can be recycled. The recycled material could be a paper, plastic, bottle or any of your choice. **Write a detailed report** on the process of recycling the material you have chosen. Include photographs or pictures of the process if you can.

Systems thinking

(20)

PART D: Water allocation in South Africa

The table below shows the total allocation of surface water in South Africa. Use the information in the table and the knowledge of water allocation and availability to answer the questions.

Table1. Surface water allocation in South Africa

Allocation of total surface water	Percentage (%)
Major dams	70
Environmental Reserve	20
Farms dams and polluted water	10

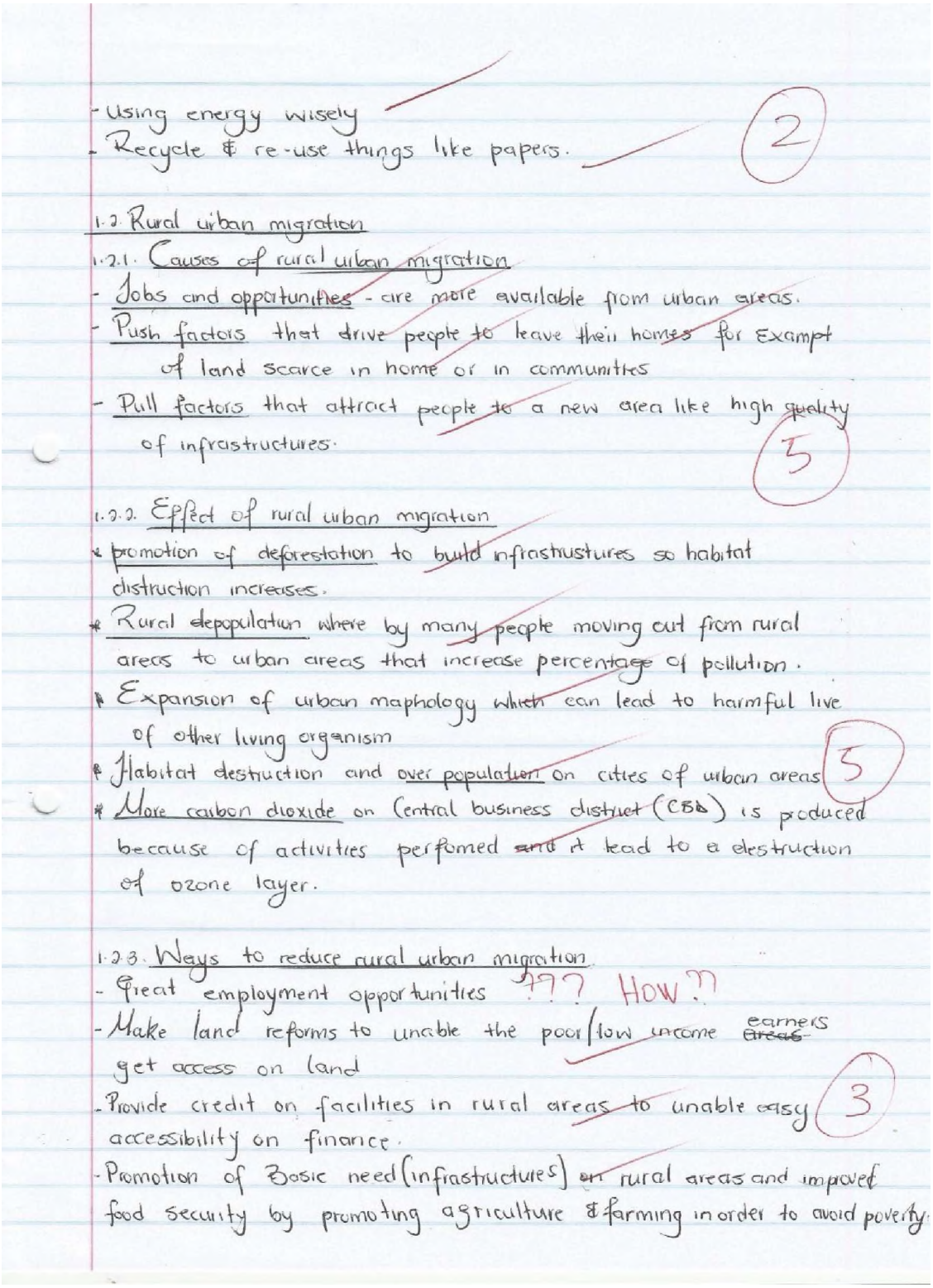
Illustrate medium / Define (LOW) / Define (LOW)

1. Use the data given a table above to draw a pie chart. (10) (Medium)
2. What is the environmental reserve? (2) (LOW)
3. Explain why South Africa has begun to export water from other countries. (2)
4. What is a wetland? (2)

Systems thinking

(16)

Appendix 5.4: Sample of DBL Learner's work



- Using energy wisely
- Recycle & re-use things like papers. 2

1.2. Rural urban migration

1.2.1. Causes of rural urban migration

- Jobs and opportunities - are more available from urban areas.
- Push factors that drive people to leave their homes for Exampt of land scarce in home or in communities
- Pull factors that attract people to a new area like high quality of infrastructures. 3

1.2.2. Effect of rural urban migration

* promotion of deforestation to build infrastrustures so habitat distruction increases.
* Rural depopulation where by many people moving out from rural areas to urban areas that increase percentage of pollution.
* Expansion of urban maphology which can lead to harmful live of other living organism
* Habitat destruction and over population on cities of urban areas 3
* More carbon dioxide on Central business district (CBD) is produced because of activities performed and it lead to a destruction of ozone layer.

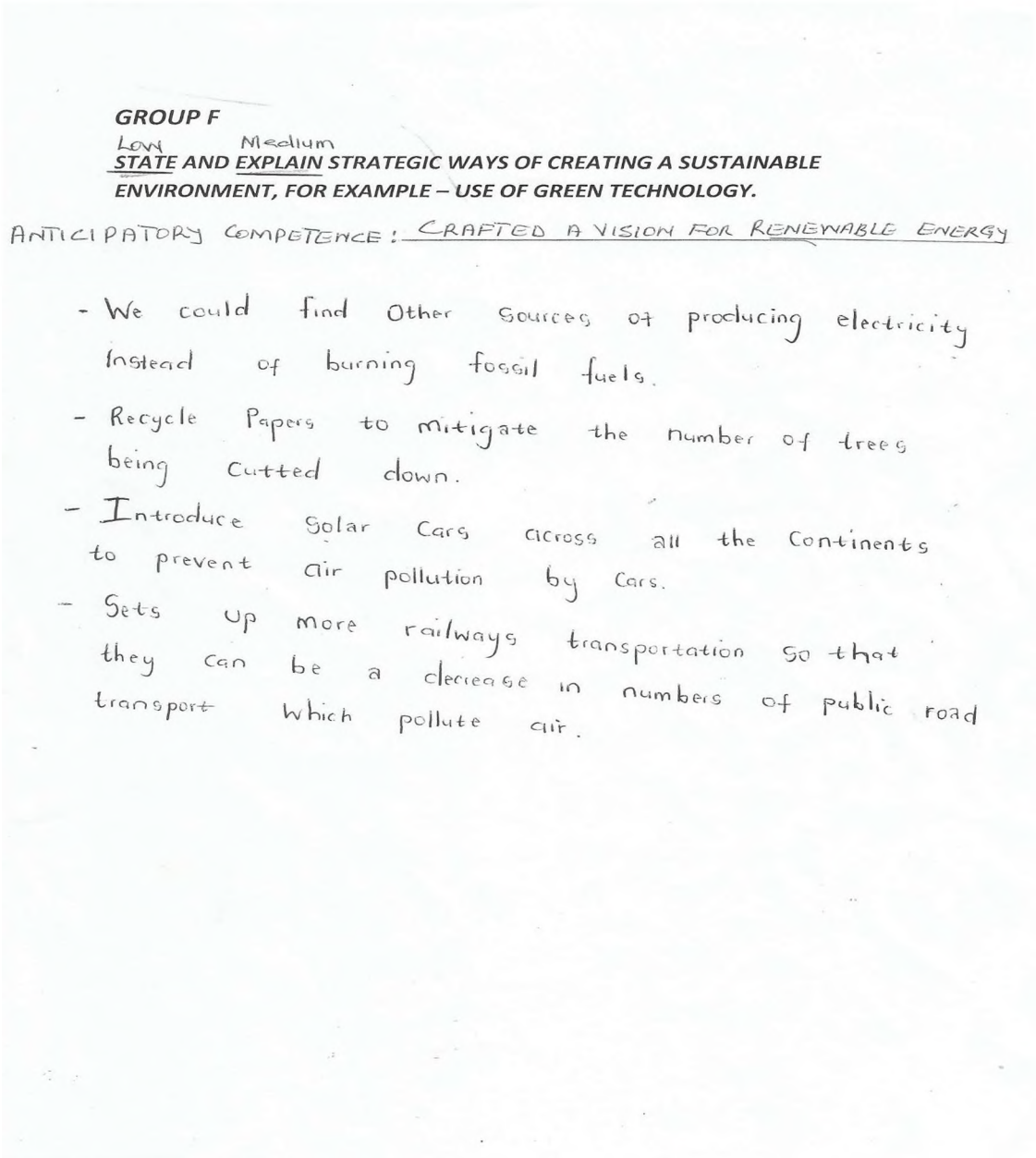
1.2.3. Ways to reduce rural urban migration

- Great employment opportunities ??? How ??
- Make land reforms to unable the poor/low income earners ~~areas~~ get access on land
- Provide credit on facilities in rural areas to unable easy accessibility on finance. 3
- Promotion of Basic need (infrastructures) on rural areas and improved food security by promoting agriculture & farming in order to avoid poverty.

Appendix 5.5: Group Assessment task 1- Atmosphere and greenhouse effect

Group A: Discuss the Process of greenhouse	Discuss	High
Group B: Name greenhouse gases and [explain] how they are produced.	Name	Low
	Explain	Medium
Group C: Explain Human activities that produce greenhouse gases.	Explain	Medium
Group D :Discuss the Effects of Greenhouse gases	Discuss	High
Group E - South Africa in seventy years will have a temperature rises of about 3 degrees Celsius. Calculate the annual rise over the given period of time. Predict how the effects of such a phenomena to South Africa in 70 years to come.	Calculate	Medium
	Predict	Medium
Group F: Suggest strategic ways of creating a sustainable environment for example use of green technology.	Explain	medium

Appendix 5.6: Sample of CON Learner's work 1



GROUP F

Low Medium

STATE AND EXPLAIN STRATEGIC WAYS OF CREATING A SUSTAINABLE ENVIRONMENT, FOR EXAMPLE – USE OF GREEN TECHNOLOGY.

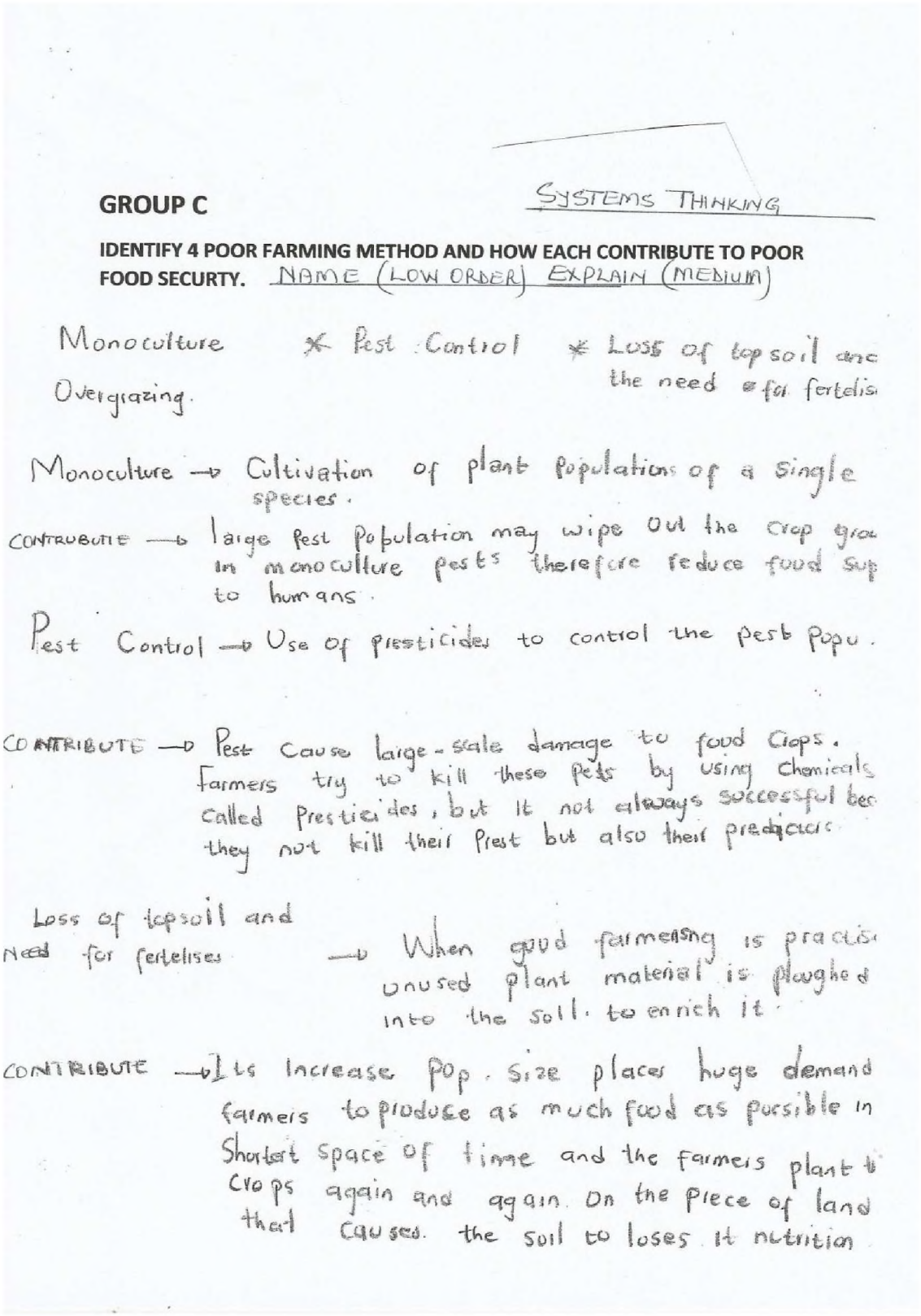
ANTICIPATORY COMPETENCE: CRAFTED A VISION FOR RENEWABLE ENERGY

- We could find Other Sources of producing electricity Instead of burning fossil fuels.
- Recycle Papers to mitigate the number of trees being Cutted down.
- Introduce Solar Cars across all the Continents to prevent air pollution by Cars.
- Sets up more railways transportation so that they can be a decrease in numbers of public road transport which pollute air.

Appendix 5.7: CON – Food security assessment task 2

	Cognitive skill	Cognitive level
Group A Question: Explain briefly how human growth pattern impacts on the food security	Explain	Medium
Group B: Explain how natural occurrences like drought, floods, climate change can affect food security?	Explain	Medium
Group C and D: Name four poor farming methods and discuss how each contributes to food insecurity. Define monoculture and explain how is it linked to food insecurity?	Name	Low
	Discuss	High
	Define Explain	Low
Group E: Predict how petrol prices will contribute to food insecurity in South Africa?	Predict	Medium
Group F: Identify intervention measures that can be taken to address the problem of food insecurity in South Africa.	Identify	Low

Appendix 5.8: Sample of leaner's work 2 – Food security



GROUP C

SYSTEMS THINKING

IDENTIFY 4 POOR FARMING METHOD AND HOW EACH CONTRIBUTE TO POOR FOOD SECURTY. NAME (LOW ORDER) EXPLAIN (MEDIUM)

Monoculture * Pest Control * Loss of topsoil and the need for fertelis

Overgrazing.

Monoculture → Cultivation of plant populations of a single species.

CONTRIBUTE → large pest population may wipe out the crop grow in monoculture pests therefore reduce food sup to humans.

Pest Control → Use of prestcides to control the pest popu.

CONTRIBUTE → Pest cause large-scale damage to food crops. Farmers try to kill these pests by using chemicals called prestcides, but it not always successful bec they not kill their Prest but also their predicacrs

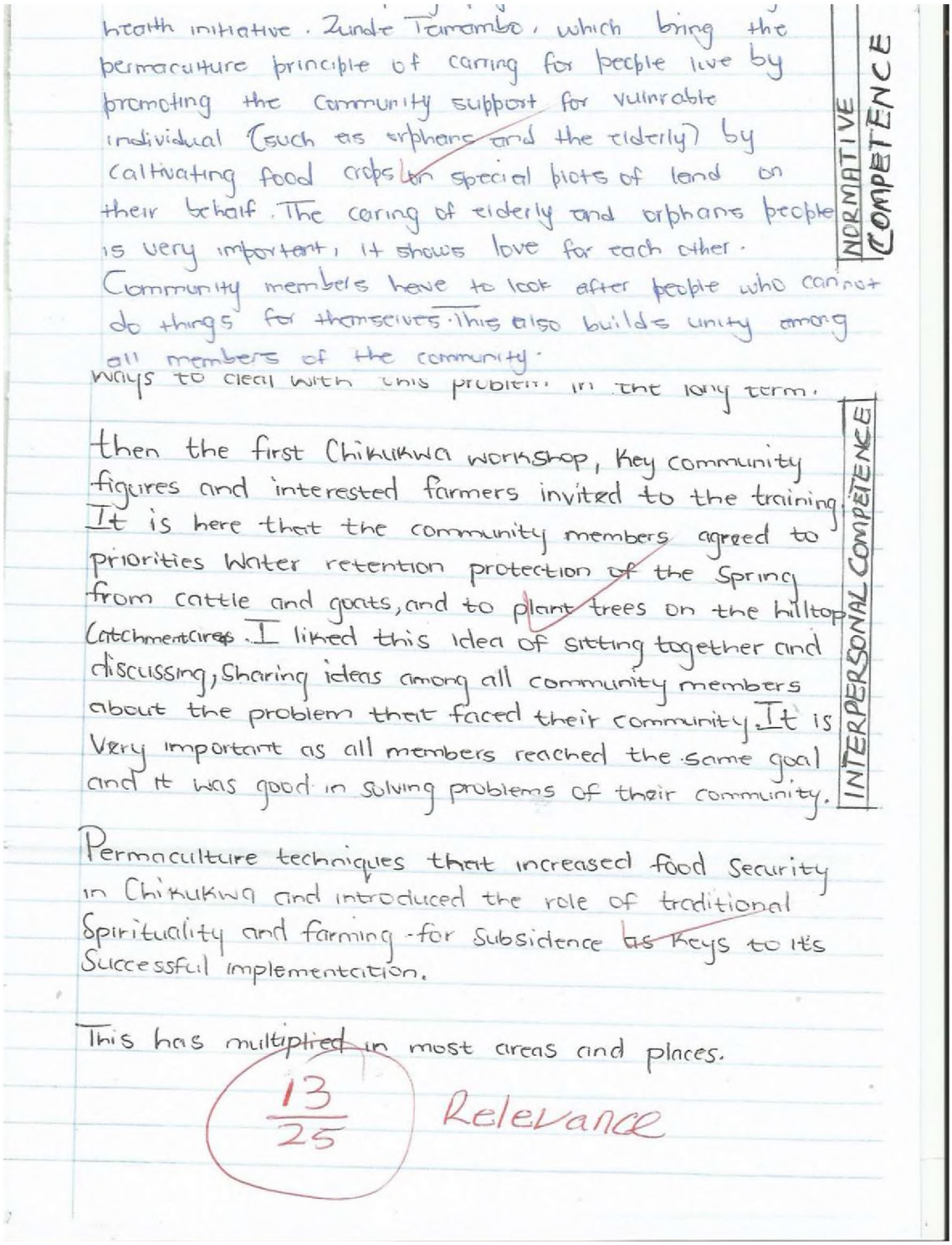
Loss of topsoil and Need for fertelises → When good farmeasng is practis unused plant material is ploughed into the soil. to enrich it

CONTRIBUTE → As increase pop. size places huge demand farmers to produce as much food as pursible in Shortest space of time and the farmers plant t crops again and again. On the piece of land that causes the soil to loses it nutrition

Appendix 5.9: CON assessment task 3- Food security

What is happening to Chimanimani area? You go and type this word Chimanimani and permaculture. Research on food security Chimanimani- Zimbabwe permaculture-Tsuro permanent culture.

Appendix 5.10: A sample of CON learner's work - Assignment Chimanimani permaculture project



health initiative. Zunde Tamambo, which bring the permaculture principle of caring for people live by promoting the community support for vulnrable individual (such as orphans and the elderly) by cultivating food crops on special plots of land on their behalf. The caring of elderly and orphans people is very important, it shows love for each other. Community members have to look after people who cannot do things for themselves. This also builds unity among all members of the community.

NORMATIVE COMPETENCE

ways to deal with this problem in the long term.

then the first Chikukwa workshop, key community figures and interested farmers invited to the training. It is here that the community members agreed to priorities Water retention protection of the Spring from cattle and goats, and to plant trees on the hilltop Catchment areas. I liked this idea of sitting together and discussing, sharing ideas among all community members about the problem that faced their community. It is very important as all members reached the same goal and it was good in solving problems of their community.

INTERPERSONAL COMPETENCE

Permaculture techniques that increased food security in Chikukwa and introduced the role of traditional Spirituality and farming for subsidence as keys to its successful implementation.

This has multiplied in most areas and places.

13/25 Relevance

Appendix 5.11: TON Assessment Task 1 (worksheet)

STUDY: WATER AVAILABILITY & QUALITY IN THE MOOI RIVER DISTRICT

NAME: _____ TOTAL: 40

1. Name the Dam that has been built on the Mooi River _____ (1) Low

2. Name the Weir where Mooi River town gets its water supply. _____ (1)

Low

3. Discuss the quality of the water found at this Weir (mention the E coli count and any other methods to determine pollution levels). _____

_____

_____

_____ (4)

High

4. Explain how dams have a huge ecological impact. _____

_____

_____

_____ (4)

Medium

5. Write a report on the state of the river and quality of water at Helen's Bridge 7km for the weir mentioned in question 2. Mention E coli content, sources of pollution as well as how to solve any pollution issues. _____

_____

_____

_____

_____

(solve)

_____(10)

Medium

6. Explain how the following affect the availability and quality of water.

Exotic trees

_____

_____(2)

Medium

(b)Destruction of wetlands.

_____

___

_____

_(2)

(c) Poor farming Practices

_____

__

_____

_ (2)

(d) Irrigation e.g. center pivots

_____

_

_____

_ (2)

7. Write a report on Weston's water management including the following factors. Sources of water, quality, conservation of water, management of liquid waste and if problems are discovered, provide realistic solutions (a digital report with photos will be accepted).

_____

_____

_____

_____

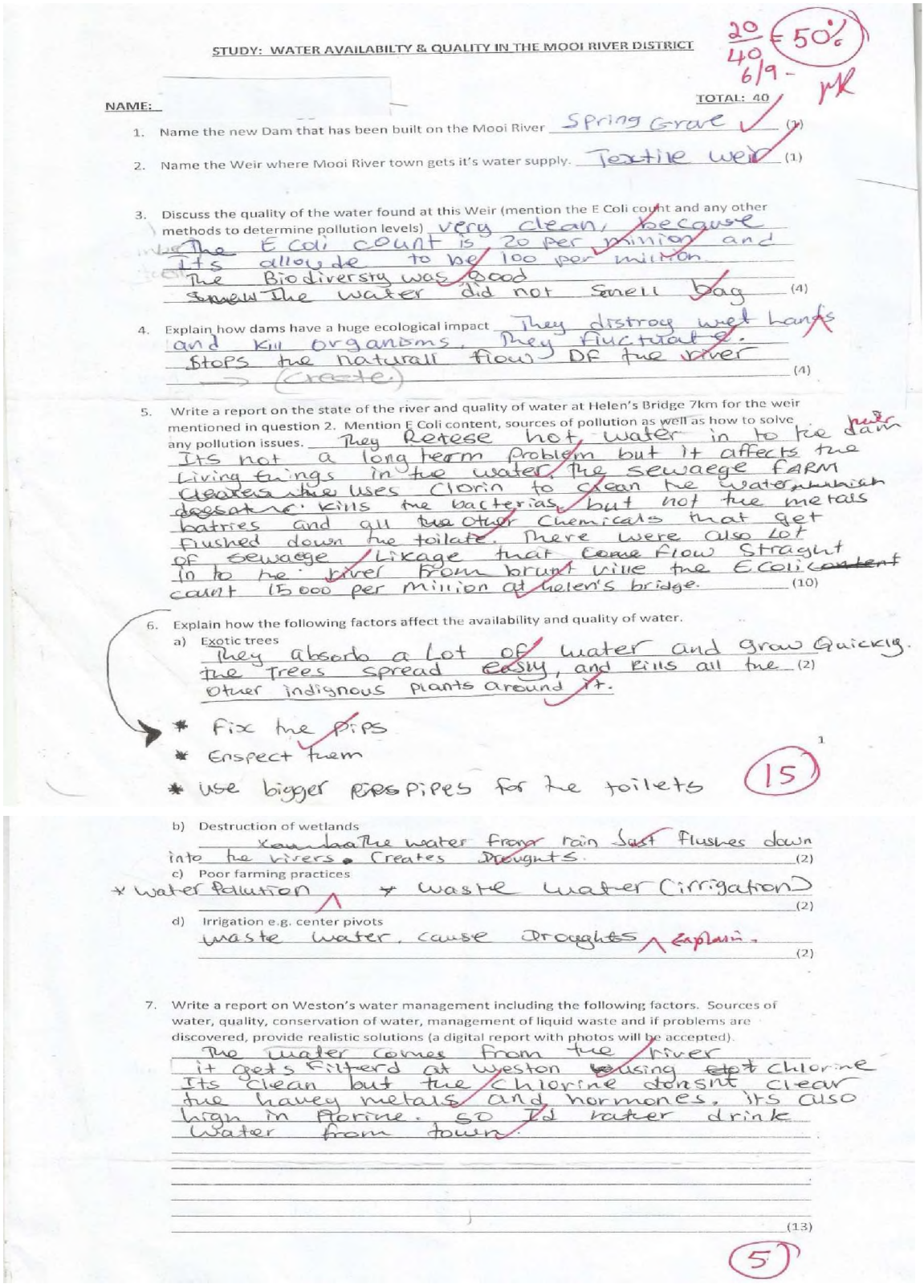
_____

_____

_____(13)

Medium

Appendix 5.12: Sample of TON learner's work 1



STUDY: WATER AVAILABILTY & QUALITY IN THE MOOI RIVER DISTRICT

20/40 = 50% 6/9 - MK

NAME:

TOTAL: 40

1. Name the new Dam that has been built on the Mooi River Spring Grove (1)
2. Name the Weir where Mooi River town gets it's water supply. Textile weir (1)
3. Discuss the quality of the water found at this Weir (mention the E Coli count and any other methods to determine pollution levels) very clean, because The E coli count is 20 per million and its allowde to be 100 per million. The Biodiversity was good The water did not smell bag (4)
4. Explain how dams have a huge ecological impact They distroy wet lands and kill organisms. they fluctuate. stops the naturall flow of the river (create) (4)
5. Write a report on the state of the river and quality of water at Helen's Bridge 7km for the weir mentioned in question 2. Mention E Coli content, sources of pollution as well as how to solve any pollution issues. They Retese hot water in to the dam Its not a long term problem but it affects the Living things in the water. the sewaege FARM Cleaners uses Clorin to clean the water which dessatroe. kills the bacterias, but not the metals batries and all the other Chemicals that get flushed down the toilate. There were also Lot of sewaege Likage that come flow Straight in to the river from brunt ville the E Coli content count 15 000 per Million at Helen's bridge. (10)
6. Explain how the following factors affect the availability and quality of water.
   a) Exotic trees
      They absorb a Lot of water and grow Quickly. the Trees spread easily, and kills all the other indignous plants around it. (2)
      * Fix the pips
      * Enspect them
      * use bigger pipes for the toilets (15)
   b) Destruction of wetlands
      The water from rain just flushes down into the rivers. Creates Droughts. (2)
   c) Poor farming practices
      * water Pollution * waste water (irrigation) (2)
   d) Irrigation e.g. center pivots
      waste water, cause droughts ^ Explain. (2)
7. Write a report on Weston's water management including the following factors. Sources of water, quality, conservation of water, management of liquid waste and if problems are discovered, provide realistic solutions (a digital report with photos will be accepted).
   The water comes from the river it gets filterd at weston using chlorine Its clean but the chlorine dosnt clear the havey metals and hormones. its also high in florine. so Id rather drink water from town. (13)
   (5)

Appendix 5.13: TON Assessment Task 2

CLASS TEST

GRADE 11 — TIME: 45 MINUTES

TERM 4 — TOTAL: 50

HUMAN IMPACT ON THE ENVIRONMENT

QUESTION 1

GIVE THE CORRECT BIOLOGICAL TERM FOR EACH OF THE FOLLOWING:

Define / Low order

1.1 The cultivation of plant population of a single species.
1.2 Chemicals used to kill pests.
1.3 The fertile upper layer of soil.
1.4 Plants that are not indigenous to an area and spread quickly replacing indigenous plants.
1.5 Human waste consisting of urine and faeces. (5)

QUESTION 2

Study the table below that shows the amount of ozone depletion in the stratosphere over a certain time period and answer the questions that follow:

Year	1982	1984	1986	1988	1990	1992	1994	1996
Ozone depletion (in ton)	2 000	3 000	4 000	3 800	6 000	7 000	8 000	6 500

Illustrate 2.1 Draw a line graph to illustrate the data in the above table. (8) Medium

2.2 Describe the ozone depletion in the given time period. (4) Low

Calculate 2.3 How many years did it take for the initial amount of ozone depletion to triple? (1) Medium

2.4 How much ozone was lost from the stratosphere in 1994? (1) Low

2.5 Are CFC's immediately removed from the atmosphere when you stop using them? Explain your answer. (2) Medium

Suggest a Reason 2.6 After 1994 the ozone depletion decreased. What do you think was the reason for this decrease? (2) High

QUESTION 3

3.1 Define the term Greenhouse effect. (2) Low

3.2 Name one way the greenhouse effect benefits the earth. (1) Low

1

3.3 Explain the effects of global warming. (5) Medium

3.4 Explain the difference between afforestation and deforestation. (2) Medium

3.5 What is the main cause of desertification in South Africa? Explain (1) Medium

3.6 Why is it necessary to manage natural resources in a sustainable way? (2) High
Suggest a reason

QUESTION 4

4.1 Explain what over utilisation means. (2) Medium

Differentiate 4.2 What do you think makes rhino poaching different from other forms of poaching? (2) High

4.3 What is meant by subsistence poaching? (1)

4.4 What gas can be harvested or recovered from landfill sites and used as an energy source? (2) Low

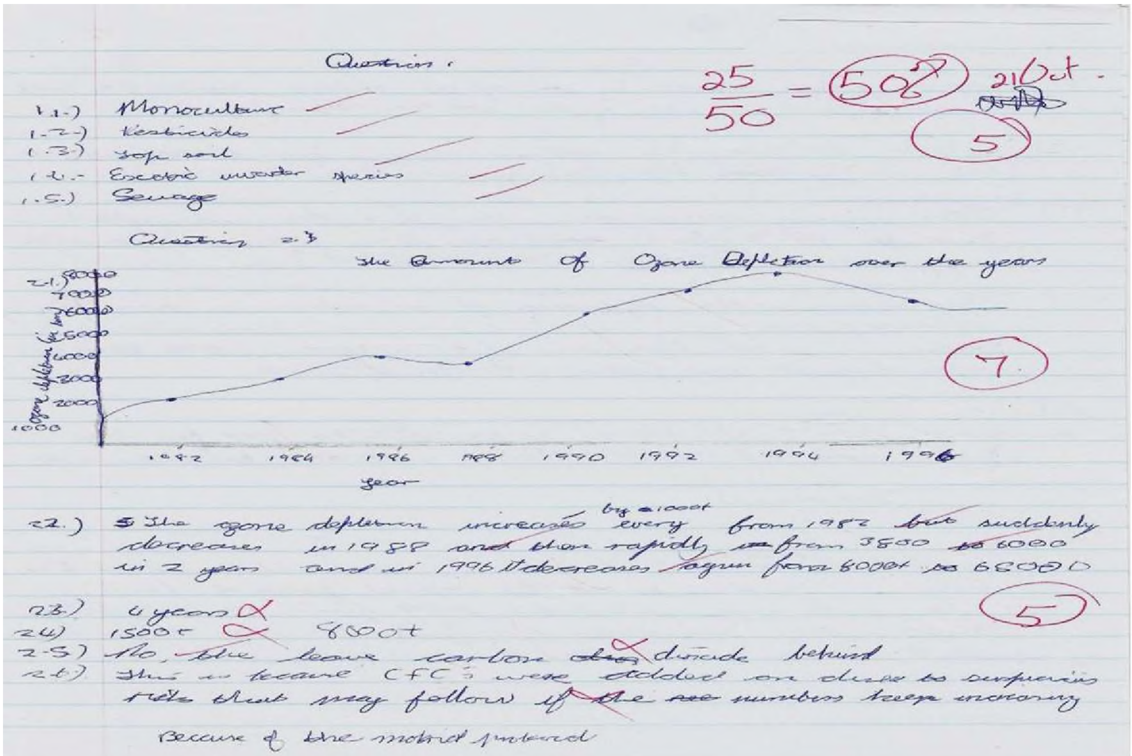
4.5 Name two sustainable energy sources. (2) Low

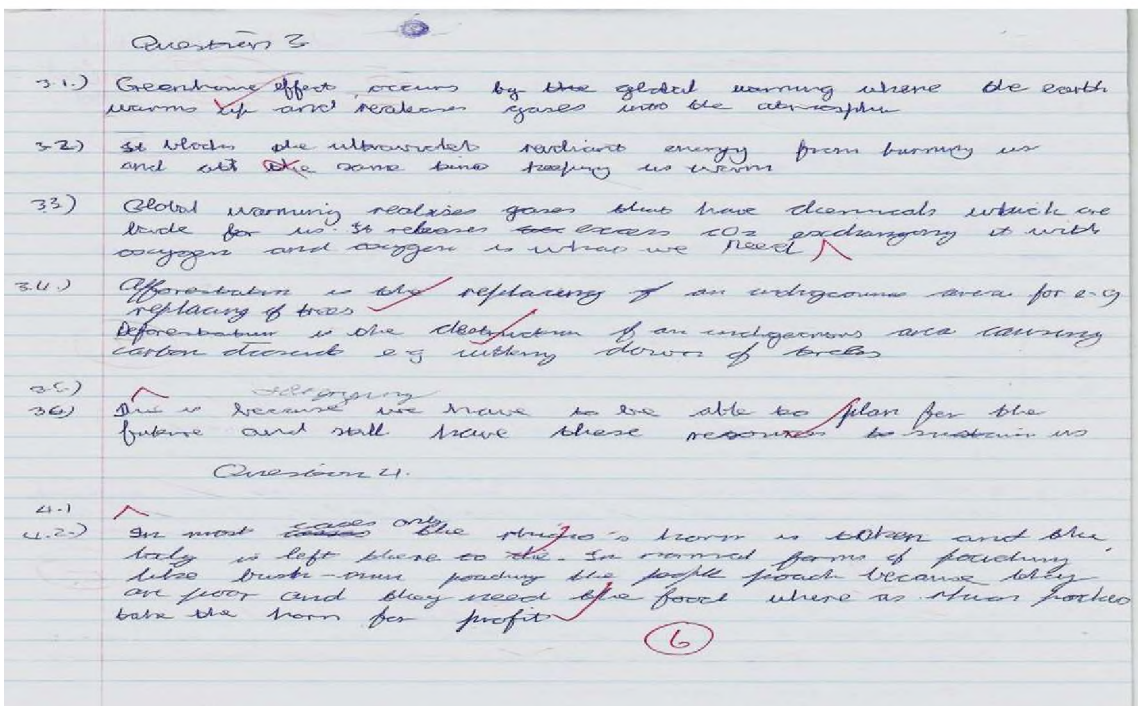
Suggest a reason 4.6 Water quality is rapidly becoming a more critical problem that water availability in South Africa. Why is this the case? (3) High

4.7 Explain the importance of carbon sinks. (2) Medium

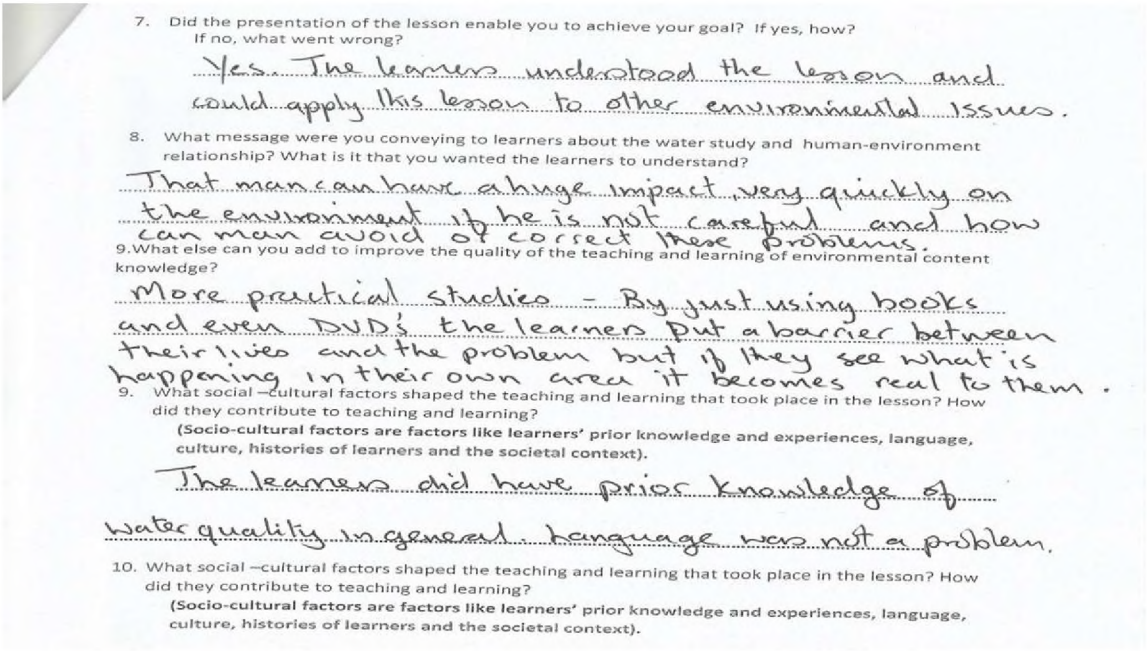
State 4.8 Give an example of the carbon sink. (1) Low

Appendix 5.14: Sample of TON leaner's work 2





Appendix 6: Additional questionnaire (TONCI)



7. Did the presentation of the lesson enable you to achieve your goal? If yes, how? If no, what went wrong?

Yes. The learners understood the lesson and could apply this lesson to other environmental issues.

8. What message were you conveying to learners about the water study and human-environment relationship? What is it that you wanted the learners to understand?

That man can have a huge impact, very quickly on the environment if he is not careful and how can man avoid of correct these problems.

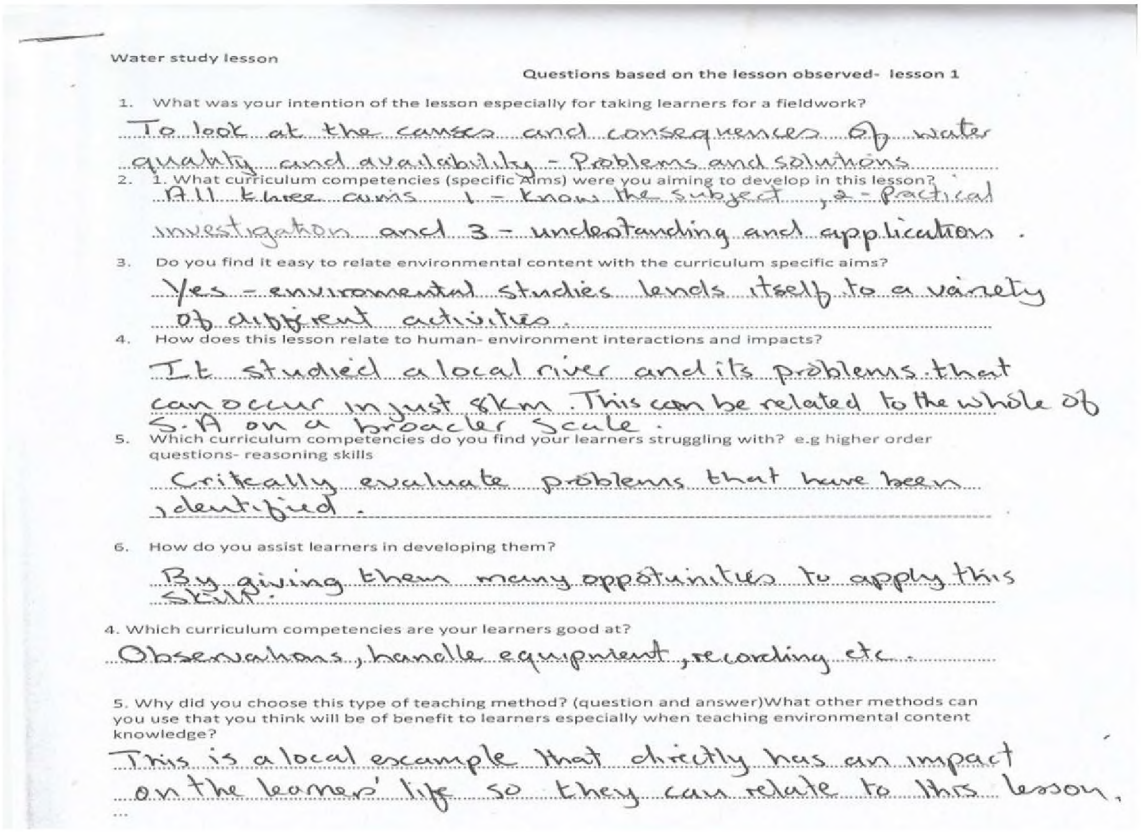
9.What else can you add to improve the quality of the teaching and learning of environmental content knowledge?

More practical studies - By just using books and even DVD's the learners put a barrier between their lives and the problem but if they see what is happening in their own area it becomes real to them.

9. What social –cultural factors shaped the teaching and learning that took place in the lesson? How did they contribute to teaching and learning?
(Socio-cultural factors are factors like learners' prior knowledge and experiences, language, culture, histories of learners and the societal context).

The learners did have prior knowledge of water quality in general. language was not a problem.

10. What social –cultural factors shaped the teaching and learning that took place in the lesson? How did they contribute to teaching and learning?
(Socio-cultural factors are factors like learners' prior knowledge and experiences, language, culture, histories of learners and the societal context).



Water study lesson

Questions based on the lesson observed- lesson 1

1. What was your intention of the lesson especially for taking learners for a fieldwork?

To look at the causes and consequences of water quality and availability - Problems and solutions

2. 1. What curriculum competencies (specific aims) were you aiming to develop in this lesson?

All three aims 1 - knows the subject, 2 - practical investigation and 3 - understanding and application.

3. Do you find it easy to relate environmental content with the curriculum specific aims?

Yes - environmental studies lends itself to a variety of different activities.

4. How does this lesson relate to human- environment interactions and impacts?

It studied a local river and its problems that can occur in just 8km. This can be related to the whole of S.A on a broader scale.

5. Which curriculum competencies do you find your learners struggling with? e.g higher order questions- reasoning skills

Critically evaluate problems that have been identified.

6. How do you assist learners in developing them?

By giving them many opportunities to apply this skill.

4. Which curriculum competencies are your learners good at?

Observations, handle equipment, recording etc.

5. Why did you choose this type of teaching method? (question and answer)What other methods can you use that you think will be of benefit to learners especially when teaching environmental content knowledge?

This is a local example that directly has an impact on the learner's life so they can relate to this lesson.

Appendix 7 (a): Letter requesting permission to visit school

28 Ridge Road
Howick
3290
22 May 2013

The Principal
School
P.O. Box 138
Nottingham Road
3280

Dear Sir

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN YOUR SCHOOL.

I am a second year Masters student in Environmental Education at Rhodes University and currently planning a research project for my thesis. The proposed research is: AN INVESTIGATION OF GRADE 11 TEACHERS' METHODS AND ASSESSMENT PRACTICES IN MEDIATING LIFE SCIENCES ENVIRONMENTAL CONTENT KNOWLEDGE AND COMPETENCIES. I request permission to conduct the research in your school this year (2014). It will be a qualitative study that will involve a grade 11 teacher. A teacher will be required to complete a questionnaire and he/she will be observed two times while teaching environmental content. These lessons will be videorised and the participating teacher will be interviewed. Each interview will be recorded. Confidentiality and anonymity will be ensured. Please feel free to contact my supervisor if you have any queries regarding the study.

Thank you

Yours sincerely

A.T. Mkhabela (Researcher) antmkh@lantic.net
0839496751
Dr. I. Schudel (Supervisor) i.schudel@ru.ac.za
0845226644

Appendix 7 (b): Letter requesting permission conduct research in schools

education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Enquiries: Philiswa Ndlovu Tel: 033 392 1053 Ref.: 2/4/8/174

Miss AT Mkhabela
P O Box 138
Nottingham Road
3280

Dear Miss Mkhabela

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"AN INVESTIGATION OF GRADE 11 TEACHERS METHODS AND ASSESSMENT PRACTICES IN MEDIATING LIFE SCIENCE ENVIRONMENTAL CONTENT KNOWLEDGE AND COMPETENCIES",** in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 01 June 2014 to 30 June 2015.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Mr. Alwar at the contact numbers below.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report / dissertation / thesis must be submitted to the research office of the Department. Please address it to The Director-Resources Planning, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education

Dabulamanzi Combined School
Senzokuhle Combined School
Shea O' Connor Combined School
Weston Agricultural College

Nkosinathi S.P. Sishi, PhD
Head of Department: Education
Date: 16 July 2014

KWAZULU-NATAL DEPARTMENT OF EDUCATION

POSTAL: Private Bag X 9137, Pietermaritzburg, 3200, KwaZulu-Natal, Republic of South Africa ...dedicated to service and performance
PHYSICAL: 247 Burger Street, Anton Lembede House, Pietermaritzburg, 3201. Tel. 033 392 1004 Fax: 033 392 1203
EMAIL ADDRESS: kehologile.connie@kzndoe.gov.za; CALL CENTRE: 0860 596 363;
WEBSITE: WWW.kzneducation.gov.za

Appendix 7(c): Teacher declaration

DECLARATION

I ..... (Full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

If you are willing to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the following equipment to be used:

Equipment	Willing	Not Willing
Video equipment	✓	
Photographic Equipment	✓	
Audio equipment	✓	

SIGNATURE OF PARTICIPANT **DATE**

..... 04/06/2014

Analytical memos

Appendix 8.1: Analytical memo 1: Contextual analysis

This analytical memo draws most data from the four contextual profiles. However there are few cases where data from stimulated interviews is included in these cases. The interviews are specifically referenced.

Category	School 1	School 2	School 3	School 4
Type of school	Farm	farm	farm	rural
Quintile	1	1	1	Fee paying
No. of teachers	14	13	21	16
No. of learners	480	297	740	180
Teacher-learner ratio	1:40	1:35	1:40	1:12
Subjects offered	Maths/ Math Lit, Acc, Life Scie, Geog, Bus.St.,Eng LO & Isizulu	Maths, Life Scie, Bus.St.,Eng, Isizulu Geog & LO	Maths/ Math Lit, Life Scie, Geog, Bus.St.,Eng, Tourism, LO & Isizulu	MathsMath/Lit, Life Scie,Geog, Bus.St.,Eng, Amp, LO & AgricTech
First language-learners	isiZulu	isiZulu	isiZulu	English
Language of instructions	English	English	English	English
School Infrastructure	Water tanks, electricity, no laboratory, shortage of books and desks,	Well equipped with resources, water and electricity	No fencing, little water and electricity supply is good	Very good condition, school situated on a 1200ha farm
Availability of resources	No laboratory, shortage of books and furniture	Library with no full relevant curriculum material and no laboratory	Well-resourced adequately	Fairly good
Teacher subject competence/ qualification	Qualified- Senior Teacher' Diploma-competent	Qualified- Bed Hons competent	BedAPPS (Bachelor's degree - Competent	Higher Diploma in Education – competent
Social factors	Illiterate, unemployment and no support from parents, learners walking long distances and not motivated.	Learners are growing growing up into isiZulu dominant area, So the teacher had to code switch for them to understand concepts better (DBLinterv.1// 21-23)	Single and child-headed families, alcohol abuse	Lack of motivation
Teaching experience	15yrs	5yrs	8yrs	28yrs
Previous pass%	40%	87%	65%	98%
Teaching methods frequently used	Question and answer, telling / lecture	Textbook approach and learner to learner	Interactive method and experiential	Various methods according to the topics
Assessment techniques & tools used	Activities, tests, projects, practicals,	Peer assessment, Rubrics,	Individual and peer assessment	Formal tests, practicals,

	assignment, rubric memo	written work, Self-study		assignments, orals & exams
Challenges facing	Materials to use during the experiments	Rely on theory from textbook	No challenges as the teacher gets help from senior teacher and eco-School facilitators who are coming to assist us at the school (CONinterv.2// 58-62).	Privileged as we can use the farm as a resource for teaching about environmental problems
CAPS workshop	Yes-useful in terms of assessment and methods	A bit useful and insightful	Yes – was quite informative the errata always follow	Yes-very good
Supporting materials	School environment, library & study guides. Especially in my school we do not have money and we have many learners. So to do practical activities that just become a problem (ZOKinterv. 1//64-65).	Only DVDs for learners to watch. The challenge of environmental content knowledge is we rely on theory that we get from textbooks. Teachers and learners need to understand it much better if it is a hands-on lesson (DBLinterv.1// 101-103).	Functional computers that are helping when learners are doing research, and textbooks although resources are not enough for the number of learners at the school (CONinterv.2// 72-78)	Microscopes, farm with different habitats

Appendix 8.2: Factors influencing emergent sustainability competencies- Goal: 2

Analytic Memo 2.1: Most data is from lesson plans and extracts from lesson observations and stimulated interviews. There are few cases where from CAPS document is included. In these cases the specific references are made.

School	ZOK	DBL	CON		TON
Lesson Plan	**1**	**1**	**1**	**2**	**1**
Topics observed	Estimating population size- mark recapture technique	Impact of human population growth on the environment	Atmosphere and greenhouse effect	Food security	Water quality
Curriculum intention	Learners will become more informed and more sensitive to environmental issues and will modify their behaviour to lessen their impact on the environment (South Africa. DBE, 2011, p.49)	Learners will become more informed and more sensitive to environmental issues and will modify their behaviour to lessen their impact on the environment (South Africa. DBE, 2011, p.49)	To emphasize the interrelatedness and interdependence of the human and the environment (South Africa.DBE,2011,p .5)	To emphasize the interrelatedness and interdependence of the human impacts and the environment (South Africa.DBE, 2011,p.5)	To emphasize the interrelatedness and interdependence of the human and the environment (South Africa.DBE,2011,p. 5)
Teacher intention	To determine a population size using simulated mark recaptures. To address the problem of calculation, application and interpretation because she knew her learners were struggling on these competencies (ZOKinterv. 1//16-20	To indicate to learners that the increase in human population growth makes increasing demands on environment. For learners to know that everything that human do in one way or another does affect the environment. So we have to preserve it (ZOKinterv.1// 8-10	To make learners aware that they have a responsibility to take care of the environment. (CONinterv1//7	To make learners aware about the impact of human population growth to food security.	To look at the causes and consequences of water quality and availability problems and solutions.
Specific aims	1,2 &3 follow instructions, estimate a population size	N/A	Not indicated	1.2.&3	1 &2
Skills	Observations &	N/A	Not indicated	Not indicated	Observation,

	calculation				recording and application
Prior knowledge	Census-direct technique	Human population growth form	Grade 10 ecosystems	Human impact on the environment	Grade 10 work
Duration	60 minutes	60 minutes	60 minutes	60 minutes	60 minutes
Content Knowledge	Under environmental studies we are talking about population ecology and human impact on the environment. ZOKobserv.1//11-12) Then under that, we are going to do to determine population size. ZOKobserv.1//15-16)	So what we are based on today, we are looking at the human population size on how it affects the environment (ZOKobserv.1//15-16)	Explain the process of greenhouse effect (CONobserv.1//148) Identify greenhouse gases and they are produced. (CONobserv.1//149) Human activities that produce greenhouse gases and the effects of greenhouse gases. (CONobserv.1//151-153) Anticipate the effects of greenhouse gases in South Africa in 70 years to come (CONobserv.1//156-157)	How human exponential growth have impact on food production (CONobserv2//179-180). how natural occurrences like drought, floods; climate change can affect food security (CONobserv2//231-232). How agricultural sector impacted on food security (CONobserv2//294-295). Intervention measures that can be taken to address the problem of food insecurity in South Africa (CONobserv2//357-358).	We are going to look at the water quality and the human impact on it (TONobserv.1//1)
Assessment	Experiment-beans	Class activity-textbook	Informal-presentations	Informal - presentations	Class activity
	Class activity	Group activity	Class activity	Research assignment	Worksheet
Resources used	Bean seeds, plastic bags, koki pens, calculators, charts	Textbook, peers, chalkboard, handouts, exercise books, pen	Charts, textbooks, Koki pens	Geography book, newspaper article, Life Sciences textbook Charts, Koki pens	E coli test results Sewage farm visit

Appendix 8.3

ANALYTIC MEMO 2.2: Analysis of teaching methods in the four schools.

Most data is from the lesson observations and interviews to further achieve Goal 2.

Analytical Memo 2.2 – Teaching methods and lesson activities – Goal 2	**Reference**
(a) Question and answers	
Q. Put your beans together right, and then let us do our practical. What is our aim in this? We are estimating the number of beans by using which method?	ZOKobserv.1//269-271
A. Estimate number of beans, using mark recaptures technique	ZOKobserv.1//272
Q. 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?	ZOKobserv.1//461-462
A.So that I will not take the marked beans only	ZOKobserv.1//464
Q. Why do we have to do this exercise five times?	ZOKobserv.1//453
A. Learner: You want to make sure that results are correct and reliable.	ZOKobserv.1//457
Q. What impact an increase in population would have on the environment?	ZOKobserv.1//531
A. If the population increases, there will be shortage of houses, water, fresh air and food	ZOKobserv.1//535
Specifically I choose question and answer because in talk and chalk, I pause a question just to find out whether they are still with me.	ZOKinterv.1//40-41
Asking them a question, two things are happening there. You go with them, you know whether they understand or not. Sometimes you will get the answer that you did not even notice that they know it.	ZOKinterv.1//53-55
According to your knowledge, we as human beings, how do we depend on environment?	DBLobserv.1//4
What do we call the process whereby plants make their own food?	DBLobserv.1//8-9
Tell me how human population size affects the environment?	DBLobserv.1//21
How is deforestation going to affect the level of CO_2 in the air?	DBLobserv.1//46-47
How will it affect the level of CO_2? Is it going to increase or decrease? What will happen if it continues to happen?	DBLobserv.1//47-49
So besides deforestation, what are other impacts the rise of human population will have on the environment?	DBLobserv.1//58-59
If we have too many criminals how will it affect the environment?	DBLobserv.1//64
When it comes to question and answer by the time you ask a learner a question, you stimulate his brain so that he can think.	DBLinterv.1//41-42
So it helps a lot that is why I chose it so that when I teach, I ask a question in between so that a learner's brain will focus on what we are doing.	DBLinterv.1//44-45
What do you understand when we say impact?	CONobserv.1//33
Let us talk about the term environment. What do you understand by it?	CONobserv.1//43
In other words we say eh, the scientific terms for living things?	CONobserv.1//53
What do you understand the term atmosphere?	CONobserv.1//73
So this part of the atmosphere is very important, why is the atmosphere important?	CONobserv.1//80
There are important gases that are good for life, for example?	CONobserv.1//83
Can you say gas is a living thing?	CONobserv.1//87
So, in fact in that atmosphere, there is a thin blanket that covers the atmosphere what do we call that blanket?	CONobserv.1//91-92
The term ecology. Who can define the term ecology?	CONobserv.1//102
Who can give us the other flow of energy?	CONobserv.1//113
So, with those gases that are produced naturally there have been there since time unknown. There were there, who can identify some of these gases?	CONobserv.1//124-125
How do humans interact with the environment?	CONobserv.1//131
Who can give us an example of fossil fuels?	CONobserv.1//203
What type of electricity that is used to generate electricity using water?	CONobserv.1//375

Who can define the term need?	CONobserv.2//8
The question and answer activities were mainly used to pour the prior knowledge that they have throughout the study from senior phase to secondary.	CONinterv.1//63-66
So who can give us the understanding of what we understand by the term population?	CONobserv.2//28
Species should be of the same found in the same area and are?	CONobserv.2//35
I think population should be there, what is needed for the population to be there?	CONobserv.2//46
There is definitely food and what else?	CONobserv.2//48
There should be a security of what?	CONobserv.2//50
So what is ecology, so that we put the definition population ecology?	CONobserv.2//54
Which one is a living thing interacting with a non-living without that they cannot live?	CONobserv.2//63
food is a source of energy; this definition is more of what?	CONobserv.2//68
We need food security. So we say food security, what is that that we are talking about? Security describes what?	CONobserv.2//77-78
Who has another definition or another view about security?	CONobserv.2//81
We are making sure that we are ensuring what?	CONobserv.2//96
Who can briefly describe the situation as South African families, are we having enough food?	CONobserv.2//114
Can you think, are we having enough of food?	CONobserv.2//115
So we going to look at the farming methods that they use, Are they sustainable? Who can give us another view about food?	CONobserv.2//121-122
Are we getting food security as we looking at South Africa?	CONobserv.2//123
What are the normal natural causes that affect food production or availability of food?	CONobserv.2//128-129
Who can comment on this fuel and food security?	CONobserv.2//130
Which means those cars that deal with transportation of food, they have to increase the prices, and so, what does that mean?	CONobserv.2//152-153
The way population is growing year to year, world population also has direct impact on what?	CONobserv.2//161
We did a test on this, we measured the E.coli count. Do you know what E.coli is?	TONobserv.1//11
It is a bacterium, but where do we normally find it?	TONobserv.1//15
All that water was lost. So what new dam was built?	TONobserv.1//31
So this building, so what do you think this pump house for?	TONobserv.1//44
So why is the pump so high?	TONobserv.1//46
What is the impact of building a dam in an environment?	TONobserv.1//52
Is it good or bad?	TONobserv.1//53
So now these trees here on the side of the river. Are they indigenous or exotic?	TONobserv.1//68-69
Its clean water but it is hot from the machine, what damage will that do to the river?	TONobserv.1//79
What difference between the oxygen supply in hot water and in cold water? Which has more and less?	TONobserv.1//81-82
How can you identify poor quality of water?	TONobserv.1//1
the smell, and what kind of the animals in water?	TONobserv.1//3
What should they do?	TONobserv.1//81-82
Why do you think you have those roters. What do those roters do, two things?	TONobserv.1//100
What kind of bacteria breaks down faeces? Anaerobic or aerobic?	TONobserv.1//103
What does it do?	TONobserv.1//105
What do we call this green when water contains too much algae in the river?	TONobserv.1//111
But in the sewage farm, that is a good thing what do the plants do?	TONobserv.1//118
What do you think this is used for?	TONobserv.1//123
Put chlorine in it. What does chlorine do?	TONobserv.1//130
But do you think that water is good?	TONobserv.1//133
What does methane gas do? What is the problem with the methane gas?	TONobserv.1//146
What is the biggest problem? What does it cause?	TONobserv.1//148
How does the water get from Drakensberg to Gauteng?	TONobserv.1//153
Do you know Sterkfontein dam in Harrismith?	TONobserv.1//154
Why is it good to stop the flow of sewage before it gets into the river?	TONobserv.1//167

So what diseases can we get?	TONobserv.1//172
But now look at the state of this river. What if you have to do a report what would you think/ What is good and bad?	TONobserv.1//219-220
Willow trees then? What is bad about it?	TONobserv.1//224
Is there something good about this river?	TONobserv.1//226
(b) Chalk and Talk	
I used telling methods most of the time because I want to explain things. My learners they do not have books, no.2, they struggle with the language. If you do not tell and explain, it becomes difficult for them.	ZOKinterv.1//58-61
So, firstly the chalk method it helps learners in terms of spelling because a learner can know a lot about environment but he cannot be good in spelling. If you have written down the word she will know how to spell it and also understanding it, he will never forget it.	Dblinterv.1//37-40
So it was imperative that we start with the knowledge from the book and also the assumed knowledge that we have in class before they embark on other activities outside the classroom.	CONinterv.1//58-60
(c) Group presentation (Strategy)	
Let us present that which we were asked and let us also contribute towards eh, let us help each other when we are doing presentations	CONobserv.1//168-169
And also give them chance to present and show if they have expressive skills to demonstrate knowledge on areas that were asked in the lesson.	CONinterv.1//64-66
Group work was meant to loosen out the opinion or to interact only with themselves and also not with the teacher. But also with the book, peer and give them time to discuss among themselves and give them room to generate more ideas and also lead them to sourcing out knowledge.	CONinterv.1//60-66
So we are going to try and break this topic and do it in groups.	CONobserv.2//165
Mark recapture technique, we are going to estimate our beans in our bottles. (experiment)	ZOKobserv.1//297
Right here I am having an activity. Let us all do this activity (worksheet)	ZOKobserv.1//534
You are going to estimate the total number of grasshoppers in the field.	ZOKobserv.1//540-541
Ok so whatever we are going to do in groups, we are going to do very fast.(group activity)	CONobserv.1//14

Appendix 8.4

Analytical memo 3: Analysis of cognitive skills and cognitive levels in the six assessment tasks. Most data is from the Informal and Formal Assessment tasks – Goal 3

		Extract	Cognitive Skill	Cognitive Level
Assessment task				
Informal Task	ZOKAT 1	1.1 Estimate the total number of grasshoppers in the field. Show all working.	Calculate	medium
		1.2 Suggest two reasons. Why the estimated size of the population may differ from the real population size	Suggest a reason	high
		1.3 State two ways in which the reliability of this method can be improved?	State	low
		2.1 Estimate the population sizes of species B. Show all working	Estimate	medium
		2.2 Estimate the total number of moths in the area. Show all working.	Estimate	medium
		2.3 Suggest why there is a difference in number between species A and B	Suggest a reason	high
		2.4 Why did the student mark the moths on the undersurface of the animals?	Give a reason	high
Formal Task	DBLAT 1	Human Impact on environment Identify 3 examples of environmental influence in your area. Write a report on each influence based on the following sub-topics.		
		(a) Its causes (b) Its effects on the environment (c) Ways to reduce the effects	Analyze Solve	High medium
		Water Availability Complete the following table to summarize the impact of human activities on water availability in South Africa. - Construction of dams - Destruction of wetlands - Poor farming practices - Boreholes - Exotic plantations - Wastage	Explain	medium
		Recycling Do a research about recycling and choose one material that can be recycled. Write a detailed report on the process of recycling the material you have chosen. Include photographs or pictures if you can.	Illustrate	medium
		Water allocation in South Africa		

		1. Use the data given in a table above to draw a pie chart	Illustrate	medium
		2. What is the environmental reserve	Define	low
		3. Explain why South Africa has begun to export water from other countries?	suggest a reason	high
		4. What is a wetland?	Define	low
		Matching	Define	low
Informal Task	CONAT 1	Explain Human activities that produce greenhouse gases.	Explain	medium
		Discuss the Effects of Greenhouse gases	Discuss	high
		Discuss the Process of greenhouse	Discuss	high
		South Africa in seventy years will have a temperature rises of about 3 degrees Celsius. Calculate the annual rise over the given period of time. **Predict** how the effects of such a phenomena to South Africa in 70 years to come.	Calculate	medium
			Predict	
		Suggest strategic ways of creating a sustainable environment for example use of green technology	Explain	medium
Informal Task	CONAT 2	Explain briefly how human growth pattern impacts on the food security	explain	medium
		Name four poor farming methods and discuss how each contributes to food insecurity. Define monoculture and explain how is it linked to food insecurity?	Name	low
			Discuss	high
			Define explain	low
		Predict how petrol prices will contribute to food insecurity in South Africa?	Predict	medium
		Identify intervention measures that can be taken to address the problem of food insecurity in South Africa.	Identify	low
Informal Task	TONAT 1	1. Name the new dam that has been built on the Mooi River.	Name	low
		2.Name the Weir where Mooi River gets its water supply.	Name	low
		3. Discuss the quality of water found at this Weir (mention the E.coli count and any other method to determine pollution levels)	Discuss	high
		4. Explain how dams have a huge ecological impact,	Explain	medium

		5. Write a report on the state of the river and quality of water at Helen's Bridge 7km for the Weir mentioned in question 2. Mention E.coli content, sources of pollution as well as how to solve any pollution issues.	Explain and solve	medium
		6. Explain how the following factors affect the availability and quality of water. (a) Exotic trees (b)Destruction of wetlands (c) Poor farming practices (d)Irrigation e.g. center pivots	Explain	medium
		7. Write a report on Weston's water management including the following factors. Sources of water, quality, conservation of water, management of liquid waste and if problems are discovered, provide realistic solutions (a digital report with photos will be accepted).	Explain solve	medium
Formal Task	TONAT 2	1.1 The cultivation of plant population of a single species.		
		1.2. Chemicals used to kill pests.		
		1.3. The fertile upper layer of soil.		
		1.4. Plants that are not indigenous to an area and spread quickly replacing indigenous plants.	Define	Low
		1.5. Human waste consisting of urine and feaces.		
		2.1. Illustrate the data in the above table.	illustrate	medium
		2.2 Describe ozone layer depletion	Describe	Low
		2.3 Calculate number of years taken for ozone layer to triple.	Calculate	medium
		2.4 How much ozone was lost from the stratosphere in 1994	Explain	medium
		2.5 Are CFC's immediately removed from the atmosphere when you stop using them? Explain your answer.	Explain	medium
		2.6 After 1994 the ozone depletion decreases. What do you think was the reason for this decrease	Suggest a reason	high
		3.1 Define the term greenhouse effect	Define	low
		3.2 Name one way the greenhouse effect benefits the earth	Name	low
		3.3 Explain the effects of global warming	Explain	medium
		3.4 Explain the difference between afforestation and deforestation	Explain	medium
Formal Task	TONAT 2	3.5 What is the main cause of desertification in South Africa?	Explain	medium

		3.6 Why is it necessary to manage natural resources in a sustainable way?	Suggest a reason	high
		4.1 Explain what over utilization mean?	Explain	medium
		4.2 What do you think makes rhino poaching different from other forms of poaching?	Differentiate	high
		4.3 What is meant by subsistence poaching?	Define	low
		4.4 What gas can be harvested or recovered from landfill sites and used as energy source?	Name	low
		4.5 Name two sustainable energy sources	Name	low
		4.6 Water quality is rapidly becoming a more critical problem that water availability in South Africa. Why is this a case?	Suggest a reason	high
		4.7 Explain the importance of carbon sinks	Explain	medium
		4.8 Give an example of carbon sink	State	low

Appendix 8.5

Analytical Memo 4: Analysis of emergence of sustainability competencies – Goal 4. Most data is from the lesson observations and assessment tasks

Lesson Observation	**Systems Thinking**	**Normative competence**	**Interpersonal competence**	**Anticipatory competence**	**Strategic competence**	**Integrated/ Processual**
ZOKobserv.1	Systems dynamics: Explained factors influencing population size (natality, mortality, immigration, emigration and migration) (ZOKobserv.1//84-87). Quantitative modelling: population estimation	No support for	No support for	In class the teacher asked learner to explain the impact an increase of population would have on the environment (ZOKobserv.1//533-535). The learners suggested shortage of houses, water, clean air and food (ZOKobserv.1//534)	No support for	No evidence of support for integration
ZOKAT 1	Quantitative modelling	No support for	No support for	No support for	No support for	No evidence of support for integration
ZOKLW1	From the calculations, all learners achieved quantitative modelling (Table 41, Q1.1, 2.1, 2.2). However the 5/6 learners were not able to answer the interpretive question (2.3) and no learners could answer critical thinking question on the mark recapture methodology	No emergent	No emergent	No emergent	No emergent	No evidence of integration
DBLobserv.1	The increase in human population size would have a negative impact on the environment (plants, the soil, and animals) (DBLobserv.1//3-5).	No emergent	No emergent	No emergent	No emergent	No emergent
DBLAT 1	A. Identify three human influences on the environment in your local area based on its causes and effects on the environment	No emergent	No emergent	No emergent	A. Identify ways to reduce the effects of human influence on the environment.	No emergent
CONobserv.1	Group B is going to identify greenhouse gases and how they are produced. CONobserv.1//148	No emergent	No emergent	Anticipate how the effect of such a phenomena to South Africa in years to come. CONobserv.1//154-156)	No emergent	No emergent
CONobserv.2	Our topic was based on identifying natural occurrences like drought, floods; climate change and how they can affect food security. CONobserv.2//231-232	No emergent	No emergent	Give an anticipatory (forecast) view on how each of the following will contribute to food security: price increase of food, fuel price increase, poverty, monopoly in seed production. CONobserv.2//329-383	No emergent	No emergent
CONAT3	The teacher verbally asked learners to research in the Tsuro Trust NGO's permaculture project in Chimanimani (CONobserv.2//410-417)	No emergent	No emergent	No emergent	No emergent	No emergent
CONLW3	No emergent	community brought permaculture principle of caring for people's lives	The learners highlighted the importance of involving all stake holders	No emergent		2 learners - evidence of integration between systems thinking,

		by promoting the community support for vulnerable individual (such as orphans and elderly)	in problem solving meeting (CONLW3).			normative and strategic Big difference between achievement levels – 4 learners only downloaded and wrote nothing.
					The community agreed to priotise water retention protection of the spring from cattle and goats and to plant trees on the hilltop catchment	
TONobserv.1	The teacher explained the impact of society, economy and technology on water availability and quality, TONobserv.1// 1-145	Water is just more important than the food we eat, seriously, because it makes 65% of your body fluid (TONobserv.1// 261-263).	No emergent	Learners anticipated diseases like cholera that might occur due to poor water quality (risks) TONobsev.1// 174	The local municipality was trying to do something about the issue of leaking sewage pipes. TONobserv.1//177-178	Yes Partly (only interpersonal competence did not emerge)
TONAT 1 (Water availability and quality Worksheet)	Question 6: How the following factors affect the availability of water: exotic trees, destruction of wetlands, poor farming practices and irrigation (center pivots) Question 7: Write a report on Weston's water management including the following factors: sources of water, quality, conservation of water and management of liquid waste	No emergent	No emergent	No emergent	Question 5: Mention E coli content, sources of pollution as well as how to solve any pollution issues. Question 7: If problems are discovered, provide realistic solutions (a digital report with photos will be accepted)	No emergent
TONAT 2 (Class Test)	No emergent	No emergent	No emergent	No emergent	No emergent	No emergent