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Exploring learning through energy dialogues in an informal learning centre

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EXPLORING LEARNING THROUGH ENERGY DIALOGUES IN AN INFORMAL LEARNING CENTRE

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A research report submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg in fulfilment of the partial requirement of the degree of Master of Science.
Johannesburg, 2012

DECLARATION

I declare that this research report is my own unaided work. It is being submitted for the degree of Master of Science (Science Education) at the University of Witwatersrand, Johannesburg. It has not been previously submitted for any degree or examination at any other university.

ABSTRACT

Campaigns to educate people on how to use and manage energy responsibly are on the agenda of energy producers, Non-Governmental Organisations (NGO) and the government of South Africa. Until recently, publications on energy conservation programmes to inform these groups on best practice have been non-existent.

This paper reports on an energy conservation programme, "Energy Dialogues" primarily aimed at offering information as well as influencing pro-environmental attitudes and consequently the behaviour of grade 11 learners in the Gauteng province of South Africa. The Energy Dialogues was conducted in a non-formal learning environment. Learners on the programme were challenged to propose various forms of 'action taking' to promote Energy Dialogues amongst their peers, in their school, at home, and in their community. Seven out of twenty schools met the challenge.

The research project captured the social interaction among learners during the "Energy Dialogues" programme. A survey confirmed that learners still possess alternative ideas with regards to energy use and management after classroom instruction. While learners have significant knowledge of the causes and consequences of poor energy usage, this does not translate into change in behaviour. Creating an environment of group learning may influence the learners' lifestyle choices. Learners are more inclined to align themselves with the values of a group. An active learning framework of the Energy Dialogues gave learners an opportunity to take personal responsibility for the environment. They redefined their culture, physically engaged in activity and spoke the language of the educator.

While the learners' visit to DEC was a one-time occurrence, and the findings cannot be generalised, this study may inform future longitudinal research which would offer information of the causal relationships of the components influencing sustainable practices.

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ABBREVIATIONS AND ACRONYMS

NGO	Nongovernmental Organisation
OPEC	Organisation of the Petroleum Exporting Countries
PROCEL	National program of conservation of electrical energy
CONPET	National program for rational use of oil and natural gas
DEC	Delta Environmental Centre
UNEP	United Nations Environmental Programme
UNESCO	United Nations Education, Science and Cultural Organisation
IPCC	Intergovernmental Panel on Climate Change
HREC	Human Research Ethics Committee
GDE	Gauteng Department of Education
NCS	National Curriculum Statement
LRC	Learner Representative Council
ICT	Information Communication Technology
CO_2	Carbon dioxide
W	Watt
Kwh	Kilowatt hour
LOC	Locus of control
EO	Education Officer

1 INTRODUCTION

In view of the changing climate, depletion of natural resources, rising oil prices and natural disasters, education in South Africa is in dire need of a better social and public awareness programme to highlight the importance of sustainable energy-use principles. Campaigns to educate people on how to use and manage energy responsibly are on the agenda of energy producers, government and Non-Governmental Organisations (NGOs) of South Africa.

An "Energy Dialogues" programme was proposed to the Gauteng Department of Education by Delta Environmental Centre. The purpose of the programme was to endorse sustainable principles and approaches to energy use. Grade 11 learners were challenged to propose various forms of "action taking" to promote Energy Dialogues amongst their peers, in their school, at home, and in their communities. Seven out of twenty schools met the challenge. This report captures a snapshot of the Energy Dialogues of one of the seven schools. The snapshot includes an assessment of the learners' background knowledge, experience at Delta Environmental centre and the impact of the intervention on the learners. The analysis of the dialogues examined the learning process, whilst the follow up visits determined the effect of the programme on the learners' attitudes towards sustainable practices.

In this chapter I offer some critical information on the energy crises, highlighting the need for energy education for change. The chapter concludes with a rationale for this study and the organisation of my report.

1.1. About Energy

Energy is an abstract concept and is not easily understood (van Huis & van den Berg, 1993). According to Hobson, (2003, p 111) "every physical process can be understood in terms of energy transformations". Chemical energy and thermal energy from burning fossil fuels has been transformed into electrical energy since the dawn of the industrial era. van Huis and van den Berg (1993, p 146), add that "energy is a dominant concept in discussions about natural resources, the environment and industry" Undoubtedly then, understanding energy use and management is critical for all industrialised nations.

There are different forms of energy which includes, heat (thermal), light, electromagnetic, electrical, and chemical, sound, wave, mechanical, nuclear and gravitational. Fossil fuels are sources of thermal and chemical energy which include oil, coal and natural gas. Fossil fuels

are a convenient source of energy, having a high intensity. The energy of fossil fuels is easily captured and converted to useful forms of energy. They do, however, release carbon dioxide captured by photosynthesis millions of years ago. Fossil fuels are non-renewable, unsustainable and are notorious for having adverse effects on the environment. Alternative renewable and sustainable energy sources have been sought worldwide, making up approximately 8% of the world's energy consumption (BP, 2011). Renewable energy technologies include: concentrating solar power, photovoltaic cells, hydrogen fuel cells, wind turbines, geothermal technologies, bio fuels and hydroelectricity. The applicability of renewable energy resources in South Africa is discussed in section 1.1.3. Whereas, sections 1.1.1 and 1.1.2 highlight key issues including global security and the environmental issues that influence energy policies.

1.1.1 *The global security issue*

Energy use and management is a global security issue. Dependence on oil has resulted in land invasions and wars since the early 1970s (McKay, 2010). Oil and natural gases are non-renewable energy sources that are threatened by limited supply. Oil production and demand has declined, as shown in Figure 1 (Oelsner, 2007). Nonetheless, it remains the most dominant fuel source in the world, maintaining a 33, 6 % share in total energy consumption in 2011 (BP, 2011). The BP statistical review reports that the world oil and natural gas reserves in 2010 may meet 46.2 % and 58.6 % years of global production, respectively.

While Europe and Eurasia are strongly dependent on natural gas, South Africa is dependent on coal. Coal is the largest non-renewable energy reserve in South Africa, which makes up 70 % of the country's energy supply (Kenny, 2006). The increasing demand for energy is a key issue, globally and within the boundaries of South Africa. The coal reserves are decreasing considerably. Reports from BP (2011) indicate that with the current production in coal, the coal reserves of South Africa may last for another 119 years. The supply of coal is not the only threat, the gross carbon emissions from coal usage adds another dimension to the energy crises. The environmental issues with regard to carbon emissions are discussed in the following section.

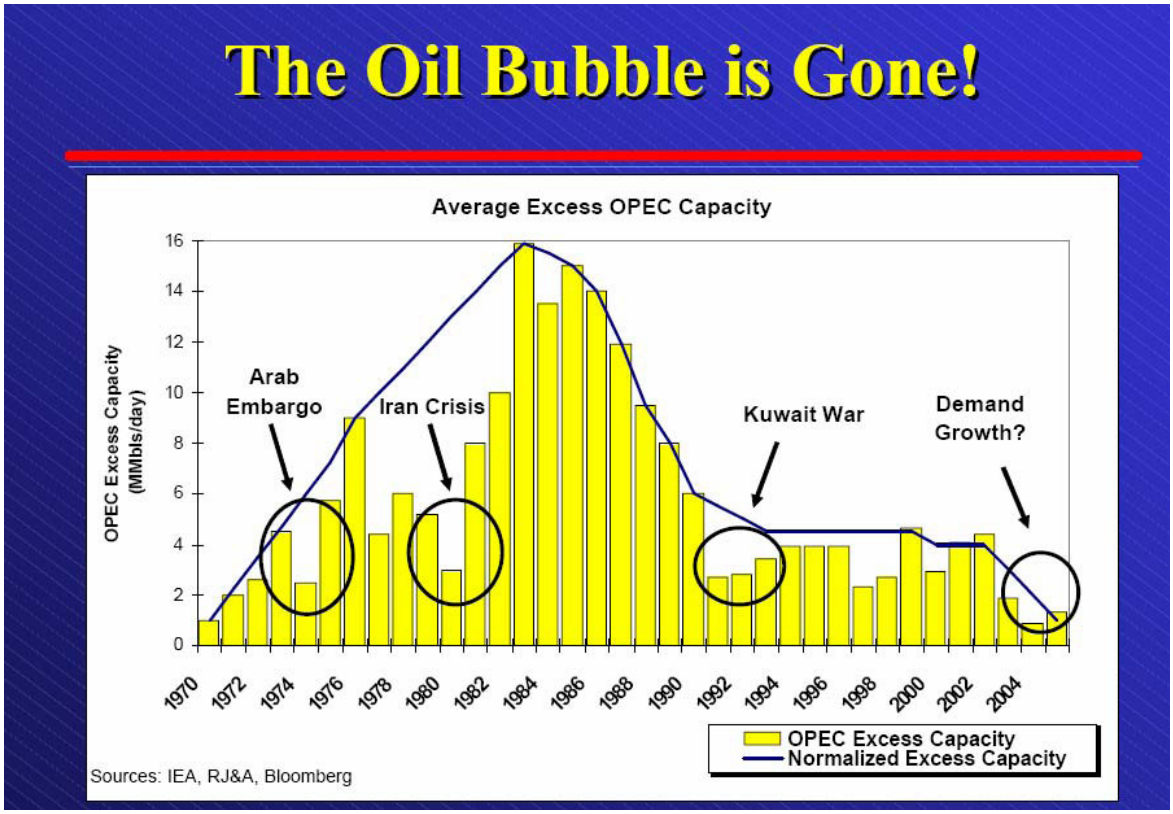


Figure 1: Trends of the global oil demand

(Source: Oelsner, 2007)

1.1.2 *The environmental issues*

The "greenhouse effect" is a factor of the interchange of energy in various environments (Broster, Carter and James, 2009). In the Earth's atmosphere, two forms of energy are prevalent, solar radiation emitted by the sun and infrared radiation emitted by the Earth's surface. Solar radiation has a higher frequency than infrared radiation. Figure 2 demonstrates the greenhouse effect. Short-wave solar radiation passes through the atmosphere and is absorbed by the Earth's surface, while low frequency, long-wave infrared radiation emitted by the Earth's surface is absorbed by greenhouse gases. Greenhouse gases include carbon dioxide, water vapour, carbon monoxide, methane and ozone in the troposphere, and oxides of nitrogen and sulphur in the atmosphere. Energy interchange occurs at this interface and heat energy is released. A considerable amount of heat absorbed in the atmosphere ensures that the Earth stays warm enough to ensure life on Earth (Luenddecke, Pinter, McManus, 2001). Luenddecke *et* al., confirm that the greenhouse effect is a naturally occurring phenomenon. High concentrations of greenhouse gases in the atmosphere, however, enhance the greenhouse effect and consequently have severe implications on the environment (Houghton, 1991, 2004). According to Omer (2008), the combustion of energy fuels

contributes to high greenhouse gas emissions including 5.3 billion metric tons of carbon. This equates to approximately 390 ppm of carbon dioxide in the atmosphere (Isdo and Isdo, 2011).

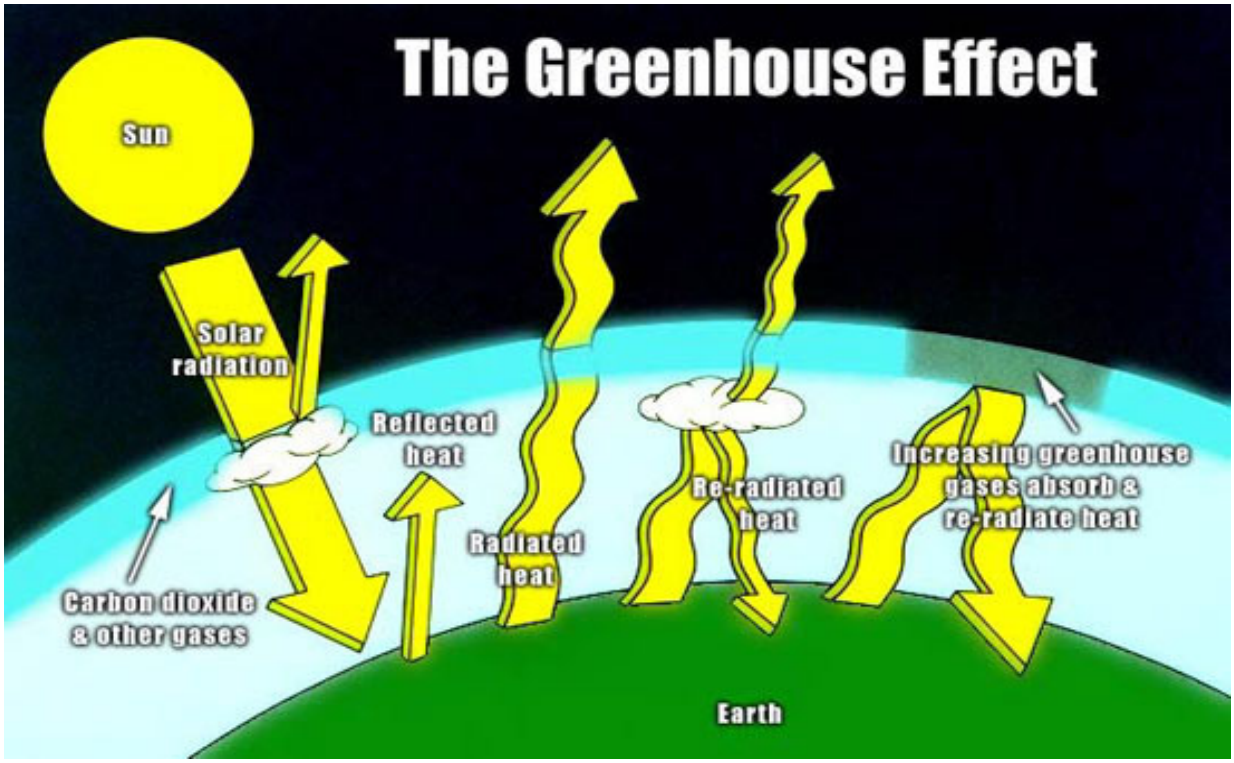


Figure 2: The greenhouse effect

(Source: www.muchupaedia.com), site visited 7 July 2011.

Energy trapped as heat in the atmosphere ultimately increases the temperature of the Earth. The increase in temperature is referred to as global warming (Dalton *et al.,* 2006). The climatic conditions may alter significantly as a result of higher temperatures. According to Goldemberg (2007), the average temperature has increased by 0.8% since the pre-industrialised era, almost 200 years ago. Evaporation, precipitation and circulation patterns are vulnerable to changes in temperature in the atmosphere. Higher evaporation rates result in extreme changes in rainfall patterns. Climate change is, however, not a new phenomenon, it occurs without anthropogenic activity. The main concern is that it may occur at an unnatural rate which may have a deleterious effect on ecosystems, agriculture and human survival.

In South Africa, the transport sector, mining sector, power stations and biomass fuel production contribute significantly to greenhouse gas emissions with coal–related resources being the greatest contributor (Sparks, 2006). Mass car usage has become a growing source for greenhouse gas emissions and is a significant consumer of non-renewable energy (Davis,

1991). Industries are not solely to blame for poor use and management of energy, because individuals also use energy frequently for heating and lighting in their homes.

1.1.3 Energy efficiency and renewable energy technology

Energy efficient and renewable-energy technologies offer solutions to the global security crisis and environmental threats. Energy efficiency involves transforming energy from one form to another while maintaining minimum losses in unusable energy. A car that is energy efficient transforms the chemical energy of petroleum into mechanical energy, with a limited amount of unused energy lost to heat. The United States uses 5-6 % more energy than Japan during manufacturing because Japan uses more efficient machinery (McKinney and Schoch, 1998). Improvements in technology may reduce energy consumption considerably.

Promoting renewable energy technologies was identified as the key strategy to reduce greenhouse gas emissions at the proceedings of the Kyoto protocol (Schamadinger and Marland, 1998). Renewable energy technology is not feasible for all countries in the world. According to Kenny (2006), potential for implementing renewable resources in South Africa is limited. South African land is mostly arid, which reduces the potential for sustaining bio-fuel production. Large bio fuel plants require dedicated energy crops and trees. The country has few small rivers for hydroelectric power generation; wind power is limited to coastal areas, while solar power has the greatest potential for alleviating the demand for energy from coal to generate electricity (Kenny, 2006). According to Winkler (2009, p 22), the residential energy policy is limited to the following:

- Solar water heating units and geyser blankets
- Fluorescent lighting
- Efficient housing with improved insulation
- Switching from electric cooking devices to Liquefied Petroleum gas devices.

Solar photovoltaic electricity is commonly used in rural areas (Kenny, 2006). In 1999 the department of energy aimed to deliver 350 000 solar home systems (SHS) to people living in rural areas (Prasad, 2006). Prasad adds that the systems are subsidised, but the homeowners still pay five times more than grid connected customers because of the high capital costs of manufacturing the units. Furthermore, there are environmental drawbacks of the components of these systems (Sparks, 2006) explains:

- Solar panels may be highly toxic and produce high Greenhouse gas (GHG) emissions during production.
- Fluorescent lights are energy efficient, but contain mercury. Fluorescent lights that are not properly disposed of may be detrimental to all living things, including humans, as mercury is toxic.
- Poorly managed used batteries that charge photovoltaic systems run the risk of contaminating the food chain as they contain heavy metals (including lead and arsenic compounds).

Educating people on the use and safe disposal of the components of these systems is vital. Goldemberg (2007) warns that implementing renewable technologies in developing countries often fails as there is lack of the necessary logistical support, infrastructure and technical expertise. The slow progress of implementing efficient and renewable energy technology in South Africa leaves the South African citizen with only one other choice to reduce the security and environmental issues: a lifestyle that is endorsed by sustainable energy principles and approaches. A sustainable lifestyle is attained by those that have the necessary information to make informed decisions. This leads to the important role of the energy conservation programme, the Energy Dialogues.

1.2. The Energy Dialogues Programme

The Energy Dialogues programme was developed for Grade 11 geography students. In general, energy dialogues are globally held amongst government officials, non-governmental organisations (NGOs), and the private sector. The idea of the Energy Dialogues is to allow participants to exchange views on energy issues including policies which govern decisions of energy use and management, the markets and environmental issues (EU-OPEC, 2005). Shell SA hope to engage all stakeholders, including schools, in productive dialogues on sustainable energy principles and approaches as part of their social and environment responsibility programme to educate their consumers. Delta Environmental Centre was identified by Shell SA as a critical stakeholder to assist with initiating Energy Dialogues in the education sector.

1.2.1 Delta Environmental Centre

Delta Environmental Centre (DEC) is an informal centre and is also known as the South African Conservation Centre (Pillay, 2008). It is located in the suburb of Victory Park, Johannesburg, Gauteng Province in South Africa. According to Pillay, DEC has played a

critical pioneering role in environmental education since the 1970s. The current mission pledge (see Appendix A) is as follows:

- to create an awareness about environmental issues by imparting /sharing appropriate knowledge;
- to introduce new skills and enhance the skills of existing participants;
- to develop responsible values and attitudes to the environment; and
- to encourage participation in environmental "action projects".

The centre provides interactive exhibits as well as education and training programmes to teach people how to manage the environment and resources in a sustainable way including reusing, recycling and reducing (Pillay, 2008). The facilities include a bird sanctuary, three dams, a sensory trail, a waste recycling centre, a water testing service, a museum, an insect collection and an aquarium. The museum itself consists of an Eskom Energy exhibition, a Rand Water exhibition and a geoscience exhibition. The centre is a non-profit organisation which is funded by various donors. According to Pillay, partnerships, project-based proposals, sponsorships and consultancy work are the major sources of income. The centre, therefore, has its own challenges to attain and maintain the necessary resources to successfully carry out its mission. In addition to other programmes, the activities of the Energy Dialogues project require its own resources. The centre has the necessary resources to incorporate the formal instruction, curriculum through integration and implementation including education officers with technical expertise, hands-on exhibits and readable elements. The learners then were given activities adapted to the geography curriculum.

The Energy Dialogues programme, designed by DEC, was an "active" learning framework which included activities to initiate discussions on **sustainable energy principles and approaches** among learners. An active learning framework involves three cyclic steps of investigation (Pillay, 2008):

- find information;
- explore and question;
- act and report.

The activities and resources at DEC involved;

- a pen and paper activity (worksheets);
- an investigative activity (energy audit);

- an interactive activity (group discussion) and
- physical activities (energy campaign).

The activities and resources for Grade 11 recommended by the National Curriculum Statement (NCS) for this theme are:

- classify energy under renewable and non-renewable energy ;
- apply skills and knowledge to energy use.

The assessment criteria and learning outcomes of the themes may be found in the work schedule of the National Curriculum Statement (NCS) for geography Grade 11-2010 (see Appendix B). The activities and resources recommended in the work schedule are aimed at achieving Learning Outcomes 1 and 3. Learning Outcome 1 includes geography skills and techniques. The techniques include, planning, acquiring, classifying and analysing information, as well as being able to write a report. Learning Outcome 3 addresses learners' application skills. The learners are required to examine the consequences on, and the human values and attitudes to environmental issues.

1.2.2 *The activities*

The Energy Dialogues programme included a pre-visit activity, an educational excursion to DEC where learners interacted with exhibits on "sustainable energy principles and approaches" and a post-visit by education officers to the schools to assist learners in promoting energy dialogues in their communities. The educational excursion to DEC occurred during a school day aimed to address the energy and waste management topic with particular reference to the theme "sustainable energy principles and approaches" in which learners considered different approaches to energy conservation.

The excursion was developed to last for four hours. During the excursion learners were required to engage in a variety of activities to build relevant knowledge, skills and values. The learners then completed task sheets and audit sheets (see instructions of the worksheet in Appendix C). The first activity was prepared at four different stations at the DEC. One station is outside the centre at a recycling display, another in the energy room, a third in the museum and the fourth in the meeting room. The learners were divided into two groups. The groups rotated from one location to another.

- The first activity was a scavenger hunt, where the groups were given clues and a map to help them find the answers to the questions put to them. The content covered included resource use and management, distribution of non-renewable energy resources, understanding the concept of fossil fuels and basic energy concepts.
- The second activity involved a personal energy audit. The learners were given an opportunity to assess their personal energy usage. This activity was aimed at making the learners aware of the use and management of energy in their personal lives.
- The third activity in the energy room was an experiment which aimed to mediate the conceptual understanding of the greenhouse effect.
- The energy campaign (activity 4) involved the whole group. Learners on the programme were challenged to propose various forms of "action taking" to promote energy dialogues amongst their peers, in their school, at home, and in their own community. The goal of the Energy Dialogues programme was to complement the geography curriculum, promote sustainable energy use principles and consequently energy campaigns in communities of South Africa.

The first activity involved the learners' interaction with the exhibits created by the curators of the centre and is thus significant for this study. The final activity, the energy campaign formed a critical part of the study as it provided information on the effect of the Energy Dialogues. Reasons to research the programme are discussed further in the next section, the rationale of my study.

1.3. Rationale

The success of energy policy is dependent on the individual's contribution to the agenda of sustainable energy principles and approaches. Learners are significant consumers of energy and are thus critical stakeholders in this agenda (Banciu and Alexandru, 2011). The study by Banciu and Alexandru recognises that secondary schools in Romania, on average use 194 Kw per year, emitting 110.93 Kg of carbon. The authors assert that creating energy-management programmes at schools can save between 20-25% on the average energy consumption. This is crucial when considering that sustainable energy principles and approaches of the future will be strongly influenced by the behaviour and lifestyles of today's youth.

The current education system has noted the importance of this situation as efforts to inform learners about sustainable energy principles and approaches are evident in the curriculum. Whether the information offered to learners has any impact on their attitudes on sustainable principles and approaches to energy use is unknown. This unknown forms the basis of this report's exploration of energy conservation in South Africa. As there is no published research on energy conservation programmes in South African schools I offer further justification for researching the Energy Dialogues programme in this section.

1.3.1 Researching the Energy Dialogues

The energy crisis is complicated, carrying with it a host of issues. It is critical that we move towards developing best practice in energy education to find sustainable solutions. Researching the Energy Dialogues programme as opposed to the standardised school curriculum has been well justified for the following reasons:

- The curriculum includes sustainable energy principles and approaches; the implementation of the curriculum has, however, not been successful. Educators are required to teach in context, which means that appropriate learning activities to develop learner's skills, encourage critical thinking and understanding should be created (Maoto and Wallace, 2006). Most schools in South Africa have the capacity to inform the learners on the topic but lack the resources, including knowledgeable educators to integrate school knowledge with everyday experience (Rogan, 2007). Group activities in the classroom are however reduced to educator demonstrations which generally deprive the learners of "processes of investigation", which form part of the assessment criteria of the present national curriculum (Stoffels, 2005).
- Most schools in Gauteng, South Africa have not been exposed to environmental education processes which include resource management principles (Maluleke, 2005). According to Dias, Mattos and Balestieri (2004) energy conservation programmes should be developed by people who have technical information about the social interaction processes that influence rational energy use. The authors further add that very few developing countries are developing teachers that are able to link specific knowledge to real-life problems.
- The quality of schools in South Africa varies significantly, which means that the skills and knowledge of the teachers ranges from very poor to very good (Rogan and Grayson, 2003). Good performing schools may have the capacity to apply skills and knowledge to a range of phenomena as indicated in Learning Outcome 3 of the

geography curriculum, whilst others may not. Teachers of low-performing schools use pre-packaged curriculum texts despite their criticism of the quality of the learning materials (Stoffels, 2005).

Rogan and Grayson (2003) have detailed the problems eloquently in their paper 'Towards a theory of curriculum implementation with particular reference to science education in developing countries'.

DEC created an energy conservation programme that forms part of the school curriculum (Hofstein and Rosenfeld, 1996). It is an accredited environmental education facility with the potential to alleviate some of the problems highlighted above. According to Maluleke, DEC has been the main organiser of environmental education curriculum and policy and has made major contributions to environmental education since 1998. Pillay (2008) commends DEC's neutral position on controversial issues. He argues that although DEC has an influential position with regards to environmental education, they do not impose their stance on sustainable issues in their publications. Pillay further adds that the centre uses multiple expressions to address issues of sustainable principles and approaches. The learning material created by DEC is current and may be linked to national and international events, but most importantly the centre supports sustainable development. The educators are trained for topics specifically related to environmental education. DEC has thus had a critical role in education and their efforts to improve environmental education should be documented to inform future innovations.

1.3.2 An alternative approach to learning

The Energy Dialogues programme was aimed to reinforce the curriculum through an 'active' learning framework. The framework required learners to be actively involved in their learning and to share their knowledge with others. The strategy was to encourage learners to converse through activities that are designed to emphasise the theme of sustainable energy principles and approaches. Initiating dialogue amongst learners is, however, not simple. Learners need an invitation or instruction to talk and consequently construct their own learning (van Zee et al., 2001). The Initiation, Response, Evaluation (IRE) technique is common in high schools and limits learners from 'talking science'. The IRE involves the teacher asking a question, the learners reciting a previously established answer and the teacher evaluates the learners' response (van Zee et al., 2001). The classroom environment is generally not conducive for dialogues and the context is often not familiar to the students

(Jimenez-Aleixandre, Rodriguez and Duschl, 2000). Endorsing scientific communication amongst learners therefore requires alternative teaching approaches. The alternative approach proposed by DEC cannot be ignored as it may offer the necessary solutions to improve energy education.

1.3.3 Energy conservation programmes

As discussed, to my knowledge there is no research regarding energy conservation programmes for South African schools, so I have resorted to basing my study on research conducted in other countries. Dias, Mattos and Balestieri, (2004) identified a number of energy conservation programmes in Brasil, including the national electricity conservation program (PROCEL), and the national program of rationalisation of the Use of Oil Derivative and Natural Gas (CONPET). The programmes were adapted using didactic material to teach concepts linked to energy to primary and secondary schools. Dias, Mattos and Balestieri assert that regardless of the efforts made by the government to inform people of the efficient use of energy, a change in attitude was not evident in the citizens' lifestyles. Cortese (2003) argues that merely informing people will not change their behaviour. He asserts that "we retain 80 % of what we do and 20 % of what we hear or read" (p 19). The Energy Dialogues programme had the challenge of offering information as well as influencing the learners' pro-environmental attitudes and consequently behaviour. Dias et al. suggest that the school system should implement an interdisciplinary approach that may influence learners' attitudes towards energy conservation. Research into these programmes has offered the Brasilian government some insight about the energy conservation programmes in schools. Similarly my research on the Energy Dialogues may offer the South African school system insights about learners' attitudes towards energy conservation. My research may offer baseline data in South Africa for further study on this very critical topic. Researchers in this field may use my research to develop theories and models to improve energy conservation programmes.

My research reports on the key learning outcomes of the programme and may inform educators, the Department of Education and other environmental centres on its ability to promote active learning and on the potential challenges of the programme, the learning process and outcomes of the programme. My research will be a significant contribution to education as there is a lack of literature on learning in informal centres in South Africa within the context of energy and waste management.

1.4. Research Questions

My study is guided by the following research questions:

To what extent do the Energy Dialogues at Delta Environmental Centre:

- ***Influence learners' attitude towards sustainable energy principles and approaches?***

  This question is informed by my rationale for researching the Energy Dialogues programme. Dias et al. informs us that energy education is only effective if it influences the attitudes of the learners. Assessing the learners' attitudes forms a critical part of my research.

- ***Create a space for learners to engage with the topic 'sustainable energy principles and approaches'?***

  Herrenkohl and Guerra (1998) assert that learners engage better with a topic if the programme offers an environment where learners are socially and cognitively stimulated. The inadequacy of the South African education system to promote active learning in the classroom has been highlighted. It was important to determine whether the informal learning environment improves learner participation.

- ***Promote collaborative learning and offer the learners an opportunity to be actively involved in their own learning?***

  This question focuses on the learning process. The issues highlighted in section 1.1 imply that energy education is in need of critical thinkers and problem solvers. Literature on group work makes strong claims about collaborative learning. Many authors assert that learners are involved in their learning; they share ideas, verify ideas, question, criticise, take risks in their learning experience and take responsibility for working on tasks (Blumenfeld et al., 1996; Shibley and Zimmaro, 2002; Dillenbourg et al., 1996; Mason and Santi, 1998; Dillenbourg, 1999 and Dolmans et al., 2001). Collaborative learning is thus considered a form of active learning. Shibley and Zimmaro (2002) report that collaborative learning has a significant effect on learners' attitude towards science, which may effectively change the learners view on the subject.

The rationale for the research questions is made clearer in the next chapter, the literature review.

1.5. Organisation of the research report

I have structured this report to offer the reader an opportunity to make meaning of the study. It comprises six chapters, including this chapter, the introduction and rationale for the study. Literature regarding environmental citizenship, science education in South Africa, environmental education, informal learning, group learning and theories on learning are reviewed in Chapter 2. Chapter 3 describes the research design, the role of the participants, as well as the strengths and weaknesses of the instruments chosen for data collection. Chapter 4 unfolds the events highlighting snapshots of the dialogues. Chapter 5 offers an understanding of the learners' learning experience. The conclusion, Chapter 6 of the report, draws together the key points of the study with a focus on some of the research responses, implications of the study and a reflection of my learning experience on this journey.

2 LITERATURE REVIEW

2.1. Introduction

In the literature review, my aim is to give a solid background to this study. The chapter is divided into two parts. The first part hopes to offer a holistic understanding of the context of the study. The information reported was collated throughout the study, before and after data collection. The theoretical framework forms the second part of this chapter.

The first part of my review consists of six sections, including the introduction. I have highlighted the on-going interaction within the international community on the environmental issues and the factors that influenced the environmental movements. Section two describes explores the interventions that have changed the environmental attitudes and behaviour of the international community. In section three, I have narrowed the focus; exploring the factors that affect environmental citizenship including changes of the policies on environmental education since the beginning of the environmental movement in the 1960's. I further highlight the key factors that influence the education system in South Africa in section four, which subsequently affects environmental education and energy education in South Africa. The challenges and opportunities for environmental education in an informal learning environment in South Africa with reference to energy use and management are discussed in section s five. In section six, dialogue as an approach to find solutions to world's problems is discussed. I conclude the review with the theoretical framework. This framework refers to the key points discussed in the literature, which offers justification to explore group learning.

2.2. Addressing environmental issues globally

Conferences, conventions, public meetings, and summits worldwide have offered a platform for nations having different socio-economic and environmental views to meet and talk about environmental issues, and subsequently make critical decisions on managing the environment.

In the 1960's, individuals interested in environmental issues raised public awareness through cutting edge publications (Pillay, 2008). The famous publication, Silent Spring in 1962 written by Rachel Carson initiated the environmental movement (McKinney and Schoch, 1998). Subsequent environmental disasters and socio-economic changes strengthened the movement's agenda (Houghton, 2004). Hart (1996) argues that many people were still in

denial regarding their contribution to the ecological problems in the world. The United Nations Conference on the Human Environment in Stockholm, Sweden in 1972 was the first of many global interactions and further consolidated the environmental movement (UNEP, 2002). According to Clark and Timberland (1982), the number of ministries of environment increased tenfold after the conference. The UNEP document reports that the conference instigated the "spirit of compromise" amongst many nations. Furthermore the declaration of principles produced by the conference informed environmental laws in governments that recognised the environment agenda. The movement encouraged people to voice their concerns and become actively involved in managing the environment.

In the 1980's, grassroots activism played a critical role in sustainability movement. Activists included local environmental action groups. The groups communicated environmental problems through local publications and vocal debates (McKinney and Schoch, 1998). At this time, the debate on climate change and global warming had started. Two schools of thought regarding the rising CO_2 levels were at logger-heads. In 1989, the members of the Intergovernmental Panel on Climate Change (IPCC) argued that the rising levels of CO_2 as a result of anthropogenic activities had accelerated the greenhouse effect and consequently caused global warming (Houghton, 2004). The IPCC declared a 90 % certainty with regards to the causes of climate change (Goldemberg, 2007). Isdo and Isdo (2011) criticize the IPCC, arguing that there is no evidence of the causal relationship of the rising CO_2 and climate change. It has been 22 years since the declaration of the IPCC and the debate is still ongoing. The findings of the IPCC have, however, been taken seriously after much persuasion. Goldemberg reports that governments from the industrialised world finally signed a treaty, the Kyoto Protocol in 1997, committing to reduce greenhouse gas emissions by 5.2 %. Australia and the United States of America (USA), who are major emitters of carbon dioxide, did not sign the treaty. Pollution prevention became a key strategy to reduce the greenhouse effect, ensure continuous improvement efforts to reduce waste and manage energy. Resources were recycled and facilities were co-located to minimise transportation and logistical issues. Hart (1997) asserts that pollution prevention, product stewardship and developing clean technology are key strategies that may guide organisations to create a sustainable world.

Product stewardship and cleaner technology became more prevalent in the 1990's. These strategies were initiated and enforced by different conferences including the United Nations Conference on Environment and Development held in Brasil, 1992 and the World Summit on

sustainable development (UNEP, 2002). Product stewardship involved "creating products that are easier to recover, reuse or recycle" (Hart, 1997, p 72). These may be classified as "green products". Green products are defined by Chen and Chai (2010) as "products that incorporate strategies in recycling." The study by Chen and Chai highlight that green product purchases are strongly related to the response of the government, therefore government policies play a fundamental role in creating a demand for sustainable energy consumption. According to Goldemberg (2007), the good intentions to reduce emissions did not materialise, and the greenhouse gas emissions had increased by 17 % in 2007. Most of the countries failed to implement their policies with regards to reducing greenhouse gas emissions.

Whilst the governments' role is significant in creating and enforcing energy policies, the responsibility to implement policy rests to a large extent with the citizens. Stern (1986) argues that the distorted visions are a consequence of energy policies that are based on economic theory that does not include non-economic behaviour of the energy consumer. Non-economic behaviour includes social norms, culture, belief structures and values. A shift in awareness and motivation to participate in finding solutions for the global energy crises is critical. Ellinor and Gerard (1998) value dialogue as a key way to moving forward. The authors assert that dialogue has the potential to deepen peoples' thinking and offer new ways of solving problems as it makes a strong appeal to collective thinking. Bakobi, Chleshi and Sgazzin (1999) further add that effective mechanisms for dialogue and co-operation amongst governments and society are necessary to implement environmental education policy. In the following section, I have explored components that effect environmental citizenship that may have a major influence on the success or failure of energy policies and education.

2.3. Environmental citizenship

Environmental citizenship appears to have a wide variety of definitions and interpretations. Governments, organisations and different groups having their own agendas may define environmental citizenship to suit their individual missions. Environmental Canada's definition of environmental citizenship is as follows,

> "Environmental citizenship is a personal commitment to learning more about the environment and to taking responsible environmental action. Environmental citizenship encourages individuals, communities and organizations to think about the environmental rights and responsibilities we all

have as residents of planet Earth environmental citizenship means caring for the Earth and caring for Canada" (MacGregor and Szerszynski, 2003, p.8).

Bell (2004) notes that the definition of environmental citizenship is complex and may be ambiguous. He further adds that the phrase 'personal commitment' in the definition offered by Environmental Canada suggests that environmental citizenship is voluntary, although the phrase 'environmental rights and responsibilities we have as residents of planet earth' suggests that environmental citizenry is a duty. Bell places a huge emphasis on the duties of an environmental citizen, stating that an environmental citizen has a duty to obey just laws; and to promote environmental justice across the world. Bell's stance is political and radical; he promotes laws that limit citizens' freedom, for the sake of protecting the integrity of the environment. He explains that among other environmental laws, prohibiting cars may impact a citizen's freedom of movement but may ensure that provision of basic needs of current and future generations of citizens are maintained. Dobson (2003) argues that standards and regulations may improve behaviour but may fail to influence the attitude of the individuals. He reports on a road pricing scheme to prohibit car usage in the city of Durham (in northern England). A road pricing scheme was implemented to alleviate traffic in the city. City drivers were fined two pounds and subsequently traffic was cut by 90 % within a few months. The road users reduced their carbon footprint without their intention of doing so. The citizens had a pro-environmental behaviour without a pro-environmental attitude. In agreement with Dobson, there is a huge risk that the behaviour of the citizens will not be sustained if the pricing scheme is not retained. Similarly, in organisations, environmental education-based tasks in the workplace do not necessarily transfer to employees' homes (Barry, 2004). Policies that influence behaviour may have no impact on individuals' pro-environmental attitudes. Bell further adds that the duties of the liberal environmental citizen do not include 'green' causes. In my view, Bell's definition of environmental citizenship is restrictive and may not be easily implemented. Furthermore, a number of components may influence the implementation of policy and the public's participation in the law developing process. In agreement with Berkowitz, Ford and Brewer (2004), "environmental citizenship is having the motivation, self-confidence, and awareness of one's values, and the practical wisdom and ability to put one's civics and ecological literacy into action. Environmental citizenship involves empowering people to have the knowledge, skills, and attitudes needed to identify their values and goals with respect to the environment and to act accordingly, based on the best knowledge of choices and consequences" (p 228). The environmental citizen essentially

protects the ecosystem. The views on environmental citizenship inform us on the people's response to energy conservation policy and programmes.

Hawthorne and Alabaster (1999) identified nine components that effect environmental citizenship; environmental information, environmental awareness, environmental concern (positive environmental attitude), personality variables, socio-demographic variables, environmental education, environmental knowledge, environmental literacy and environmental responsible behaviour. The model developed by the authors is very complex and the components have very strong causal relationships that overlap each other (Figure 3).

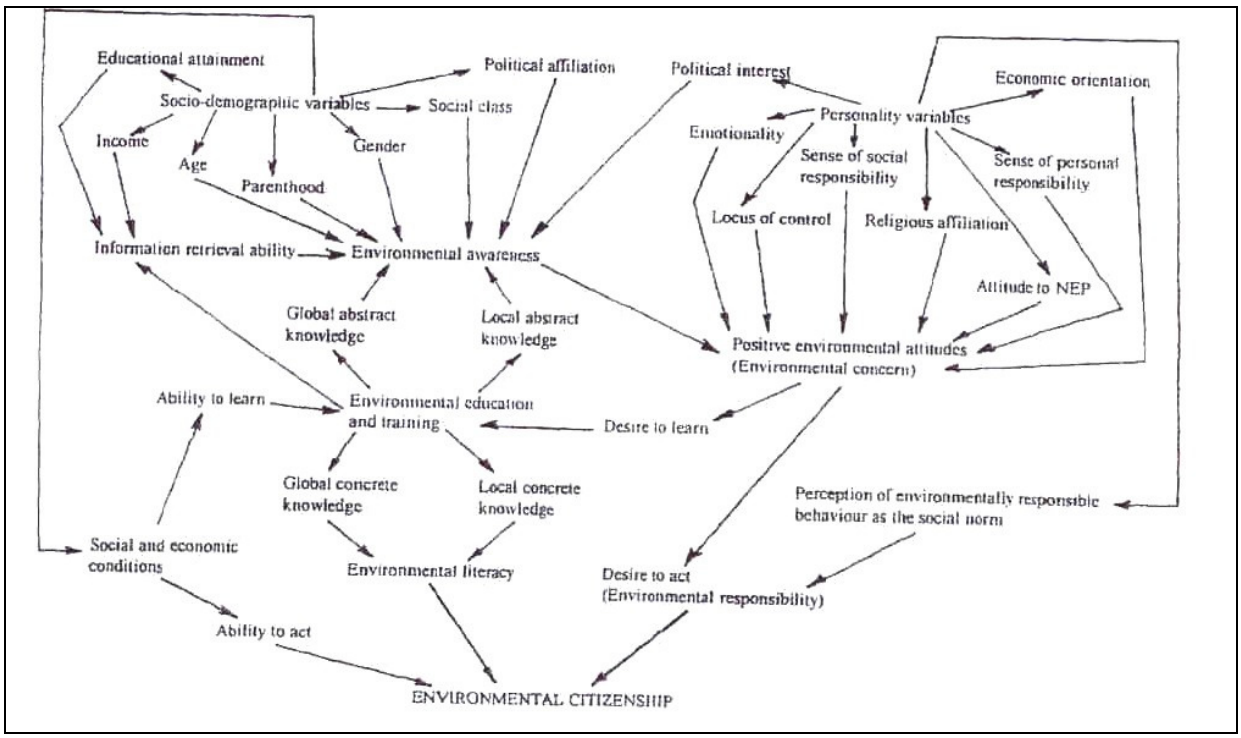


Figure 3: Environmental citizenship (Hawthorn and Alabaster, 1999)

Environmental concern is the main component used in this study as it may inform me on the learners' desire to act. Environmental concern (positive environmental attitudes) is in informed by the learners' environmental awareness and their personality variables (Hawthorn and Alabaster, 1999). In section 2.3.1 and 2.3.2, the factors that influence environmental awareness and personality variables are further discussed.

2.3.1 Environmental awareness

Environmental awareness is influenced by socio-demographic variables, political affiliations, environmental knowledge and information that citizens hold. Peoples' response to the price of technology has thus been a key factor in modelling energy policies (Stern, 1986). They affect the environment directly and indirectly, as they give power to make decisions about the environment (Stapp, 1969). Stapp further adds that citizens cast votes on issues related to the environment; they have purchasing power with regards to energy related products and their lifestyle practices that determine the demand for energy related products. Economic assumptions about consumer behaviour have resulted in poor practices of energy use. Stern argues that a range of other behavioural factors that may influence the success of policy are ignored. This includes the role of information, people's commitment, social influences (e.g. government role), people's values and beliefs, communication, marketing and implementation. A number of reasons with regards to incorrect and insufficient information have been addressed in literature.

- Hansen (2009) argues that the media plays a significant role in misinforming the public.
- McKinney and Schoch (1998) argue that information overload and a lack of environmental wisdom is responsible for poor spending. The authors define environmental wisdom as the "ability to sort through facts to make the right decisions" (p 5).
- "Green washing" is defined by McKinney and Schoch (1998) as a marketing ploy to coerce the poorly informed public to buy products that may not necessarily be environmentally friendly. Environmental information is often too technical and tainted by bias. Poorly informed individuals are susceptible to "green washing" marketing. Producers may manipulate a consumer to believing a product is green without backing up their claims.
- The presentation of the information does not grab the attention of the consumers as they are not vivid, specific or personalised. People are misinformed about residential energy. They overestimate the energy used by visible technology, for example lights, whilst underestimate the energy use of technology that they do not see, for example geysers (Stern 1986).
- According to Hawthorne and Alabaster (1999), environmental information is not easily accessible or available.

- The types of information offered to consumers are generic and lack credibility (Dias, Mattos and Balestieri, 2004). Stern (1986) reports on a study conducted by two marketing professors, which highlighted the significance of credibility. Brochures on cutting energy costs were distributed to New Yorkers apartment dwellers. Brochures mailed out on New York State Public Service Commission made a 7 % impact on energy savings, brochures mailed out on the stationery of a local electric company, made no impact.
- McKinney and Schoch further add that people often hear about a phenomenon but do not understand the consequences. Awareness about environmental issues is limited to shallow familiarity. "Global warming and climate change may have no significance to poor people who are merely trying to survive" (p 20).
- African American communities, a low income minority group in America, offer very little support towards environmental citizenship (Barkan, 2004).
- The relationship between gender and pro-environmental behaviour is a controversial one. According to Barkan (2004), previous studies report that women were less involved in participating in environmental movements. In his study he found that women have become more active. Barkan speculates that the gender gap has narrowed and women are empowered to participate more aggressively in the movement.

The public's concern for environmental issues is thus distorted as a result of ignorance. According to McKinney and Schoch (1998), the public is concerned about hazardous wastes and old dump sites, on which relatively large amounts of money are spent. The concern for more threatening problems, such as global warming and indoor radon is very low and consequently very little money is spent on solving these problems. The economic orientation is further discussed in the following section, personality variables.

2.3.2 Personality variables

Environmental concern is further attributed to the personality variables of individuals which include their emotionality, sense of personal responsibility, social sense of responsibility and their economic orientation (Hawthorne and Alabaster, 1999). The authors assert that emotionality has a stronger influence on people's attitude towards the environment than knowledge. They describe environmental concern as an emotional reaction to understanding

the consequences of the different threats to the environment. What people believe (cognition) and what they feel (affect) have been key measures of determining people's attitudes towards various social and environmental issues (Pooley and O'Connor, 2000). Social attitude is informed by cognition, or affect and/or behaviour of individuals. Pooley and O'Connor further add that behavioural change is best facilitated through affective based attitudes.

It is important to note that people's ecological behaviour may be inconsistent with their environment attitude as there are many factors that may be a hindrance to carry out ecological behaviour which they believe and feel are correct. Kaiser, Wolfin and Fuhrer (1999) assert that there is a moderate to weak relationship between environmental attitude and ecological behaviour. The phenomenon where attitude is inconsistent with actual behaviour is termed cognitive dissonance (Robbins and Judges, 2009). Individual ecological behaviour may be influenced by situational factors, such as economic constraints, social pressures and opportunities beyond people's control.

An individual's concern towards the environment may be a consequence of their ***economic orientation***. Individuals who have an orientation towards accepting economic sacrifices to ensure long term environmental protection are environmental citizens (Hawthorne and Alabaster, 1999). On the contrary, other individuals may view the Earth as a resource that is used for growth and development and consequently protect it based on material benefits it offers. Consumers will choose to use existing technology as it may be cheaper. According to Majlath (2008), perceived consumer effectiveness has the strongest influence on consumer behaviour. This is in agreement with Babcock (2009), who asserts "when there is no monetary benefit from changed behaviour, people may need incentives" (p 142). According to McKinney and Schoch, failure to promote sustainable technology is not a technical problem but a socio-economic one. They believe that the public demand for goods determines what products are produced. The public may desires green resources, but they are not cheap. Green resources are thus not high in demand. On the contrary, Myers, Saunders and Bexell (2009) assert that the environment will only be protected if we have an empathetic orientation towards it. Empathy is defined by the authors as the affective response of "sharing the perceived emotion of another" (p 44). Individuals' desire to make sacrifices for the sake of others indicates that they have a ***sense of social responsibility.*** Developing a sense of personal and social responsibility in learners thus requires an affective learning programme.

Environmental education has increased public awareness, but the knowledge is often global and abstract. Hawthorne and Alabaster assert that the global knowledge results in action

paralysis and that global knowledge on its own may leave learners with a sense of powerlessness. An interactive component of information transfer may offer learners a more personalised experience that may influence a long term behavioural change. The authors further assert that communication mechanisms that break the barriers for efficient use of energy are fundamental for energy conservation programmes. In the following section environmental education is further discussed.

2.3.3 Environmental education

"Environmental citizenship is the ultimate learning outcome of education for sustainability, a process which is all about changing people's attitudes, providing access to knowledge and developing skills which combine to influence behaviour." (Hawthorne and Alabster, 1999, p 26). Berkowitz, Ford and Brewer (2004) identified five components required for the development of education for environmental citizenship, which include ecological literacy, civic literacy, values awareness, self-efficacy and practical wisdom. The components are defined as follows:

Civic literacy is the ability to understand social, economic, political and cultural systems. The authors further add that thinking critically about the social systems in which we operate is a requisite for civic literacy. When we understand the social systems in which we live, we may be inclined to participate more responsibly in society. I have deduced that a sense of social responsibility is gained when civic literacy is attained.

Ecological literacy involves the understanding of local and global ecosystems that impact all living species including the needs and wants of humans. An understanding of ecological systems that sustain us, for example the sources for energy yielding systems (wind farms) is a product of ecological literacy.

Self-efficacy refers to the self-confidence to explore and develop personal values and interest in the environment. Strong self-efficacy may lead to an internal locus of control.

Values awareness involves making individuals aware of their own values with respect to the environment. Value awareness may inform a learner's sense of personal responsibility.

Practical wisdom empowers individuals to make decisions with respect to the environment. Self-efficacy, values awareness, and practical wisdom are informed by civic and ecological literacy.

Berkowitz, Ford and Brewer (2004) recommend that ecological literacy and civic literacy may be amalgamated, and together be viewed as environmental literacy. According to

Hawthorne and Alabaster, environmental literacy is a product of environmental education and training.

Environmental education centres generally encourage learners to become environmentally literate and consequently take environmental action towards their biophysically environmental problems (Ardoin, 2009). Learners are encouraged and expected to change their attitudes and behaviours once they have been informed of the importance of sustainable energy use and management. Ardoin argues that informing the learners on new ideas and beliefs will not lead to a more enlightened attitude. Lemke (2001) further adds that requesting someone to change their minds and lifestyle is not dependent on rational thought alone. The arguments made by Ardoin and Lemke are informed by the history of environmental education, which is discussed in more detail in the following section.

2.4. Towards a framework for environmental education

Environmental education has been the vehicle to make the public aware of their practices when interacting within their environment (Maluleke, 2005). UNESCO-UNEP has defined environmental education as

> "a process to develop a population that is aware of and concerned about the environment and its associated problems which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones" (1976, p 3).

Environmental education as defined by UNESCO has not been successfully implemented for several reasons. One prominent reason is that environmental education systems have been under constant transformation as the dialogue regarding environmental management continues. The role of environmental education has changed every decade since the 1960's (Maluleke, 2005). The changes require educators to change their methodologies in a very short time which is not easily achieved. Implementing a radical change in classroom practices requires teachers with radical personalities. Stoffels' (2005) study demonstrated that even though a teacher has all the necessary resources to teach as promoted by policy, teachers also need to be psychologically equipped to change their classroom practices.

In this section I have highlighted the evolution of environmental education as the global perspectives of the environment have changed since the 1960's. Perspectives on behaviourism, constructivism and social constructivism are discussed below. The history and

philosophies of environmental education (EE) discussed here offers justification for the role of social constructivism in EE in the 21st century.

2.4.1 Behaviourism

In the 1960's, the theory of behaviourism was adopted (Wigley, 2003). Wigley asserts that behaviourism assumes that behavioural change is dependent on the values, knowledge and attitude of the individual. According to Maluleke (2005), the behaviourist theory implies that behaviour can be modelled by teaching learners' values and attitudes. He further adds that the theory also accentuates that the educator is an expert having static, fixed and contained knowledge which can be imparted to the learner. The learner would passively accept and adjust their behaviour accordingly. With the understanding that studies about the environment are scientific in nature, this theory has a positivist view of the discipline.

During this period, the South African socio-political system still advocated autocratic leadership and this orientation towards science was thus plausible. Maluleke argues that although South Africa is under a democratic leadership, behaviourist ideology of the 1960's is still evident in schools in South Africa. South Africa's resistance to change is further discussed in the next section. Whilst school systems remained within the behaviourist paradigm, the role of environmental education changed dynamically.

2.4.2 Constructivism

In the 1970's, an interest in theories on constructivism grew. Piaget initiated a new understanding with regards to the relationship between the teacher and the learner (Demetriou Shayer and Efklides, 1992). He believed that in order for a child to know something, he/she should be able to transform, modify and understand the process of formation (Piaget, 1964, 2003). von Glasersfeld (1991) echoes Piaget by stating that we can only truly know something if we have gained experience on the subject. Learners were thus exposed to fieldwork and interactive learning was encouraged.

In the 1980's environmental education acted as a tool to address preservation and enhancement of the human environment (Maluleke, 2005). The Brundtland Commission report in 1987 emphasised the importance of education for sustainable development (Bakobi, Chleshe, and Sgazzin, 1999). According to Maluleke, environmental policies were scientific and technical in nature. It was assumed that implementing improved technology may reduce the stresses of the human activity on the environment. Scientific tools and equipment were

used to understand the environment (Wigley, 2008). Maluleke further adds that environmental education was the vehicle to make the public aware of their practices when interacting within their environment.

The intentions for environmental education during this time were indeed relevant but not easily implemented. The constructivist approach to learning was recommended, but a values-based education is preferred by educators (Ballantyne and Packer, 1996). The values-based education involves teaching learners to appreciate the environment and encouraging them to protect objects that are threatened. The values based approach encourages learners to care for the environmental but fails to address learners' conceptions. Failure to challenge the learners' conceptions may lead to environmental behaviour that is motivated by conceptions interpreted out of context or by myths. The arguments made by Ballantyne and Packer are supported by previous research on other environmental topics, such as climatology, pollution, resource use and management. Learners are easily confused with varying concepts, such as global warming, greenhouse effect, photosynthesis and ozone depletion and alike. To address these problems, peoples' alternative conceptions should be determined and creative ways of challenging the learner's conceptions should be found (Koulaidis and Christidou, 1999). This suggests that the style of teaching should induce conceptual change. According to Hewson et al. (1998), this change is achieved when ideas replacing the old ideas are intelligent, plausible and lastly fruitful. The new ideas must make better sense to the learner than the learner's previous ideas. This could be achieved through evidence based argumentation.

According to Mason and Santi, (1998, p 82), "Argumentation may be used as a tool for learners to critically evaluate the status of their own conceptions", Argumentation is frequently used to justify and validate new findings/hypothesis. Argumentation is thus encouraged in schools to promote scientific thinking. Toulmins Argument Pattern (TAP) classifies an argument based on the frequency of five categories; claims, data, warrants, backings and rebuttals (Erduran, Simon and Osborne, 2004). A claim is a hypothesis that is open to public scrutiny. Data, warrants and backings provide the evidence to a claim, they strengthen a claim, whilst a rebuttal refutes a claim. Using the TAP model, the authors further add that 'the use of rebuttals in an argument demonstrates a higher level capability with argumentation' (2004, p 927). Rebuttals in argumentation aim to refute previous ideas which are in conflict with constructivism (Smith, DiSessa and Roschelle, 1993). Constructivism aims to build on or refine old ideas. The Andrews model offers an alternative way of

measuring an argument which essentially examines the framework in which different concepts are developed and linked to validate a claim (Scholtz et al., 2008). The Andrews model is constructive as it does not require replacing of ideas, but building of ideas. It is important that scientific knowledge construction should be created by the learner in a non-confrontational manner. Constructivism promotes the building of ideas on previous ideas. Smith, DiSessa and Roschelle warn against confrontation in the classroom, in that it promotes replacement of ideas and not building of ideas. Scientific knowledge should be created in a non-confrontational manner.

Implementing cognitive conflict in South African classrooms is further challenged by heterogeneous communities with different social arrangements. Cultural and religious aspects tend to make argumentation complex. Claims based on strong cultural and religious beliefs can generally not be proved empirically, therefore warrants and backings for these claims are difficult to make or refute (Braund et al., 2007). Scholtz et al. (2008) examined the teachers' ability to participate in an argument. They also identified the factors that either facilitated or hindered the teachers' ability to initiate and sustain an argument. Their findings show that there is a strong correlation between *competence in subject* knowledge and ability to argue. They also demonstrated that *competence in language* is a prerequisite for effective idea articulation. Confrontational aspects of rebuttals intimidated teachers that were not competent in the language of instruction. Scholtz et al. note that a competent teacher, from an affluent community who teaches at a more resourceful school may have a higher level of argumentation. The authors speculate that the less competent teacher from a poorer community, having a lower qualification may feel intimidated by the articulate repartee of the more competent teachers.

Similarly, learners from poorer communities in South Africa that are instructed in English, which is generally different from the language spoken at home, struggle to understand concepts taught in the English and fail to construct knowledge with a language that is foreign to them (Djite, 2008). The majority of learners in South Africa are from working class homes and children are sent to school with an understanding only of their own home culture and lifestyle (Taylor et al., 2003). The implication of this in argumentation is that a child from a working class home is not equipped to challenge the concepts taught at school. Edelson asserts that 'Students need to accumulate knowledge to pose well-framed questions' (1997, p 4). The learners are therefore not confident to make or refute claims of concepts that are

unfamiliar and abstract to them. Activities that learners are familiar with will supply them with evidence to make warrants, back-up claims or even refute a claim (Simon and Maloney, 2007). Learners with prior knowledge or experience relevant to a learning programme are more likely to engage with the subject content on a deeper level. With greater knowledge of a subject the learner may be inclined to explain considerably more, thus contributing to the learning process. Learners' backgrounds and experiences are not considered in the school environment because a language that is foreign to them is used to construct knowledge. Shumba (1999) demonstrated that indigenous cultures, particularly in African countries have a huge impact on how knowledge is perceived and thus transformed and transferred to learners. Kyle recommends that an integrated education system has the potential to engage learners of developing countries to deal with their social, environmental and economic developmental issues. Integrating all ways of knowing may give learners "an understanding of the basic scientific concepts and an understanding of the nature of scientific enquiry" (Hobson, 2003, p 109). It is clear that promoting argumentation in South African classrooms is not easy; the challenges highlighted above may be one of the reasons why didactic approaches based on constructivism were not adopted by many educators. Education should involve the socio-cultural components that may affect learning.

2.4.3 Social constructivism

The focus of EE shifted to the community level in the 1990's (Maluleke, 2005). EE adopted a more social constructivist approach where learners challenged their social practices (Bakobi, Chleshe, and Sgazzin, 1999). Social constructivists assert that the human reality is socially and psychologically constructed (Franklin, 1995). This essentially means that the psychology of the individual is informed by the psychology of his/her society (Vygotsky, 1978). Franklin further adds that knowledge is constructed through language, culture and social processes. Environmental education was no longer bound to the classroom, but became community based (Wigley, 2003). Learners were thus encouraged to take responsibility for their practices in their immediate environment. The key focus of this approach was thus to create social awareness regarding environmental issues.

Research on programmes that initiate community based activity to promote sustainable energy use has not been well documented, although Banciu and Alexandru (2011) report on two didactical approaches. These learning approaches aim to engage learners on principles and approaches of energy management. The first approach is based on e-learning. The programme

is an interactive game called Ecoville. Ecoville is a computer simulation which may be found at the http://ecovillelejeu.com. Learners are required to build towns that practice sustainable energy use, and commit to the Kyoto Protocol, reducing greenhouse gas emissions by 8 %. The town should offer 21st century services to its citizens within a limited budget and constrained resources. This programme creates simulations of "real world" situations. It is generic and may be applied by groups worldwide. Djite (2008) argues that a learning programme that is relevant to learners is more likely to engage with the subject content on a deeper level. Djite further adds that with greater knowledge on a subject the learner may be inclined to engage considerably more, thus contributing to the learning process. Djite encourages the use of practical knowledge that learners can relate to. On the contrary, Anderson, Reder and Simon (1996) assert that abstract knowledge is effective and that knowledge can transfer between tasks, "Transfer of knowledge may occur as long as the tasks share cognitive elements" (p 7). They imply that a combination of abstract knowledge and concrete illustrations are most effective for learning.

The second approach is called the Best Young Eye manager, also known as the International Eye Manager Championship. The Championship consists of five phases. Learners are trained on energy management approaches; they are thereafter required to carry out energy audits in their schools and homes with the assistance of specialist in the field. These two phases are data collecting phases. The competition is based on case studies. The learners are then required to recommend interventions that save both money and energy for the case studies assigned to them. The learners who have the most cost effective solutions are the winners. Some of the skills of these didactic approaches are based on engineering principles. According to Carlson and Sullivan, "manipulations of building systems presents unique learning opportunities" (1998, p 27). Furthermore, learners are required to create buildings to help society, consider the costs, and the needs of the citizens, as well as the environment.

Banciu and Alexandru's study suggests that an interdisciplinary approach to learning is required, where physical science, social science, environmental science, and economics are all integrated. However, integrating disciplines may exert great pressure on both the teachers and the learners (Lewin, 2000). Coping mechanisms may address the cognitive demand required by new practices in the classroom. Lewin further adds that the level of teacher competency in science at secondary level in South Africa is low, and integrating subjects may place a greater demand on the teachers' subject matter knowledge. Rigorous training and continuing teacher

development would be needed to ensure that effective teaching occurs. The changes to the South African education system further reinforce challenges with environmental education in South Africa. The following section thus deals with the challenges of education in South Africa, with a particular reference to science education.

2.5. Education in South Africa

The South African education system has been very unstable for the past fourteen years. It had undergone radical and drastic change in response to the social and political reform in the early 1990's (Chisholm, and Leyendecker, 2008). Curriculum 2005 in South Africa was an important product of the South African political and social transformation. The reform in the 1990's formed part of a poverty reduction strategy which aimed to "open doors for prosperity and up-skill people and reduce unemployment" (Chisholm and Leyendecker, 2008, p 199). The education system has failed to improve peoples' lives as the teachers fail to cope with the curriculum. Consequently the curriculum received criticisms from across the racial and ideology spectrum (Jansen, 1999). In this section I have highlighted the challenges of the curriculum, concluding the section with opportunities of environmental education.

The C2005 curriculum in South Africa required active participation from learners and teachers. It created some necessary changes in the classroom, with the intention that learners would become more active in their learning. According to Rogan (2007), the curriculum promoted community-based learning that required learners to take responsibility for their own learning, by designing and doing their own investigations with the facilitation of the teacher. The curriculum sought learning outcomes without explicitly defining the learning process (Nykiel-Herbert, 2004). Jansen (1999) asserts that instructional methodologies were not consonant with local and culturally determined classroom practices. The policy failed to consider the existing ideas and conditions of the classroom. Rogan argues that the policies did not consider whether the schools have the capacity and resources to implement the curriculum. He further adds that the educators' buy-in (values, practices and beliefs) was disregarded and the practices were not understood. The learner-centred approach could not be accommodated by the existing classroom realities. Teachers were confused and uncertain about what was expected of them in the classroom, the role of the teacher was not explicitly stated and the teachers' subject matter knowledge was over-estimated (Rogan, 2007). A case study by Rollnick et al. (2008) on South African teachers discussed the importance of a teacher's subject knowledge. The following points were highlighted:

- Understanding the subject matter allows the teachers to be flexible and be able to adjust their lessons to ensure that teaching goals are attained.
- In depth understanding of subject matter gives the teacher the flexibility to connect different ideas and can thus produce effective representations to illustrate or explain target knowledge. Teachers who lack flexibility rely on algorithms and resort to rote teaching.
- Without adequate subject matter knowledge (SMK), teachers struggle to connect ideas and create holistic understanding.
- Inventing creative representations and opportunities to transform subject matter requires knowledge of the subject matter. Within the South African context, the challenges of lack of resources and diverse cultures, the teacher is dependent on subject matter to design instruction within the context of their environment.
- Having complete understanding of subject knowledge enables the teacher to teach in variable contexts.
- Teachers with solid SMK will create assessments that are purpose driven and examine whether meaningful learning has occurred.

Teachers lacking the necessary SMK fail to cope and resort to cutting corners and finding alternatives to keep all parties involved happy (Stoffels, 2005). Furthermore, there is an enormous range in the knowledge and skills of the teachers, many of whom lack training, confidence and commitment to teaching (Rogan and Grayson, 2003).

Implementing curriculum innovation was challenging as South Africa lacked the capacity to support innovation. The system needed to have the resources and skills, good leadership, the buy-in of all stakeholders, and the necessary processes to make the change successful (Rogan and Grayson, 2003). Rogan and Grayson add that the diversity of schools was a major factor that influenced curriculum implementation in schools. A number of schools were dysfunctional with poor resources and conditions that limited the performance of the educators. Ineffective implementation of the current education policy calls for innovative proposals to improve the education system. The principles and approaches enforced by DEC are not limited to policies developed by the department of education; they thus have the freedom of innovating new methods from different worldviews to improve learning about the world. It is thus crucial for other mediums of learning (e.g. informal learning centres) to supplement the formal education systems.

2.6. Informal learning

In formal learning environments, the teachers are responsible for imparting knowledge. The context is structured and organised. Learning in educational leisure environments takes place whether people intend to learn or not (Packer, 2006). Learning may take place in schools, libraries, museums, at work, school, and even at home (Falk and Dierking, 2002). Educators are not limited to education authorities of schools; any medium (e.g. television, radio, parents, and doctors) can inform the learner about a subject.

2.6.1 Non-formal versus free choice learning

Informal learning centres may be classified as two categories, free-choice or non-formal. In free-choice learning environments, learning is controlled by learners; learners choose what they will learn and when they will learn (Ellenbogen, 2002). Non-formal learning is semi-structured, which may limit choice and control to some extent (Colardyn and Bjornavold, 2001). The activities of non-formal learning environments are often planned. Non-formal learning centres may thus be classified as an education centre.

Prince (1990) argues that informal learning centres that are portrayed as educational centres fail to attract people as the choice and control aspects are lacking. Choice and control, motivation, interest and prior knowledge are key factors in determining whether a learner will construct their own knowledge (Falk and Storksdieck, 2005). The element of choice makes the learning experience pleasurable (Packer, 2006). Free-choice learners learn for fun, resulting in 'accidental' learning as they discover, explore and stimulate their mental capacity. Free-choice learning is not constrained by the curriculum; learners are not limited by pre-planned activities. Allen (2004) argues that the lack of accountability or guidance in free choice learning environments broadens the learning agenda and does not contribute to an authentic science experience. She further adds that exhibits may fail to communicate abstract concepts and visitors do not always recognise the intended themes. Anderson et al. (2000) confirms that the knowledge learners construct with the assistance of an exhibit, however, are not always based on standard scientific explanations. Learners develop their own theories about a phenomenon when they struggle to understand the purpose of an exhibit. Anderson et al. showed how learners use their prior knowledge and experience to make sense of new knowledge. In their study, a learner connected "a prior experience of viewing a television programme about the production of lightning in clouds to the friction effect of a magnetic field that the exhibit demonstrated" (p 678). Learners thus require the assistance of a

competent educator to manage the tension between learners' contributions and developing scientific knowledge.

Learning should not be limited to either formal or informal learning. Mixing learning contexts and methods may be very beneficial and subsequently bridge the gap between formal and informal learning (Hofstein and Rosenfeld, 1996). The authors further assert that compulsory school contexts should not be limited to formal learning methods. Hands-on exhibits offer multisensory learning modes of experience, which makes the subject matter accessible to diverse groups of people (Allen 2004). Hofstein and Rosenfeld assert that a blend of methods may accommodate heterogeneous groups, as people learn differently and have different abilities. The concrete experience of informal learning environments offer the learners opportunities to interact physically with their environment, which may result in long-lasting knowledge and may potentially attain the goals beyond knowledge. Learners' attitudes towards science and their environment may be significantly enhanced through structured exhibits as both cognitive and affective outcomes are attained.

2.6.2 The role of exhibitions and media

Exhibitions and media effectively inform learners, but how the learner perceives and internalises the information is critical. Exhibitions in museums and learning centres may be represented by different elements including hands-on exhibits, readable elements, cultural artefacts, interactive virtual technology or even live animals (Allen, 2004). Hands–on exhibits are based on constructivist theories that suggest that in order to know something one should transform information and be able to manipulate an object (Piaget, 2003). Hands-on activities may engage all senses, including touch, smell, and vision, hearing and taste. Engaging all the senses may stimulate the learning (Allen, 2004). Allen's study demonstrated that visitors engage more with live animals than hands-on exhibits. Over stimulated senses may result in cognitive overload and leave visitors feeling drained or even despondent. Foreign objects and advanced explanations may also leave people feeling alienated as they cannot engage with the learning experience (Djite, 2008).

Informal learning centres may not necessarily address all issues of a topic. It is important to re-address new ideas learners may have on a topic to reinforce the desired learning outcomes. Anderson et al. (2000) reported that conceptual mapping and post-visits gave learners in their study an opportunity to reflect on their learning and made them aware of their learning experience and achievements. The learner thus made meaning of the visit to the centre.

Lelliott and Pendlebury (2009) confirmed that inadequate preparation and follow-up only reinforces learners' misconceptions. There are dangerous consequences to informal learning without reflection or instruction. Engagement with exhibitions'/activities in informal learning must be coupled with social interaction for knowledge construction.

Newspapers and more recently web-based technologies are informal learning media, which offer other forms of social interaction. A study conducted by Hansen (2009) on Norwegian pupils confirmed that media plays a huge role in informing learners and teachers about environmental issues. Their study showed a strong correlation between the Norwegian media's knowledge construction and the learners' knowledge construction. Learners understanding of the greenhouse effect improved from 1989 to 2005 as the Norwegian media's information on the topic became more correct. Studies on the greenhouse effect are indicative of learners' understanding of energy use and management. The greenhouse effect is a key learning topic of energy use and management (Dalton et al., 2006). Hansen's study demonstrated that public interest informs the individual's interest in learning. Learners' lack of interest in the ozone depletion was evident when public concerns on the ozone layer faded; conversely, an increase on the focus of the greenhouse effect in media influenced the learners' learning on the subject. The learners' knowledge of the greenhouse effect was initially dependent on the media because information from the media preceded instruction from the school. When instruction from school became apparent, the instruction reinforced the understanding of information learners gathered from media.

Media includes website activities, which may either be non-formal or free choice. Virtual learning environments (VLE) create non-formal learning activities. Piccoli, Achmed and Ives define VLEs as "computer based environments that allow interaction and encounters with other participants" (2001, p 402). They further define VLEs as semi-structured within an environment where the learner controls the pace of their learning. Lack of structure in instruction may cause the learners to be anxious and isolated in their learning experience. VLEs are only effective for mature and motivated learners that require minimal input from instructors. Learners who are comfortable with the technology may participate collaboratively with other students. In South Africa, the cost of having ICT in all schools is prohibitive (Lewin, 2000) as ICT requires infrastructure and technically qualified staff to maintain and upgrade the equipment. Group work learning that involves interaction amongst learners is possible. Group-work activities in informal learning centres allow members of the group to

have discussions and actively contribute to their own learning. Groups visiting a learning centre are inclined to discuss their learning experience as it unfolds (Feinberg and Leinhardt, 2002). Feinberg and Leinhardt use the term discussion very loosely. Considering that my study is an assessment of Energy Dialogues, it is critical for me to clarify the distinction between discussion and dialogue. As defined by Bohm (1996) discussion is an analysis of different perceptions, and interprets the derivation of dialogue as a "stream of meaning flowing through us" (p 6). In agreement, Schein (1993) asserts that dialogue may offer a group the excitement of exploring and sharing ideas without the risk of offending anyone, compared to disagreeing and questioning, which may result in an unproductive debate. He further states that creative and critical thinking is indeed possible if disagreements are not entertained. This school of thought is significantly different from constructivism, as argumentation is not encouraged. Dialogue as an approach to promoting environment citizenship is discussed further in the following section.

2.7. On Dialogue

Dialogue allows groups to discover ideas, and share meanings of their ideas that they would not think of on their own (Schein, 1993). According to the creator of the Energy Dialogues programme, "dialogue creates opportunities to explore, expand, deepen and illuminate ideas until new meaning and understanding emerges. It is through dialogue that we can reflect and rethink our current behaviour and habits; thinking of new ways of working towards a sustainable future" (Caudwell, 2011). Dialogue is thus a process and develops over time. Bohm (1996) argues that dialogue should not entertain people's emotions and opinions, and people's beliefs should not be judged. He further asserts that the objective of dialogue is not to analyse things, win an argument or exchange opinions, but to listen to all members whether they agree or not. A study conducted by Dessel, Rogge and Garlington, (2006) report that dialogue that is purely focussed on politics may fail to build concrete relationships amongst the participants. The authors assert that intergroup dialogue may potentially harness power within communities that may transform a community. Their findings demonstrated the potential of dialogue circles whilst managing conflict within American Arab and Jewish communities in the United States. Students gained multiple perspectives and expanded their activity in outreach dialogue programmes related to the Israeli - Palestinian conflict. According to Scharmer, dialogue involves both sharing of ideas and listening (Scharmer, 2007). Scharmer identified four types of listening that may indicate how the dialogue has progressed.

- Downloading is the first type of listening in dialogue, it occurs in a space where habitual ways of thinking and judgements are shared. Downloading involves reconfirming habits and norms of the individuals.
- The second type is factual listening, which is attained when the object of focus is different from what is already known. The emphasis of listening is on facts. This type of listening may occur when the participants are in a foreign space. Factual listening is based on scientific methodology, collecting data from observation and experiences and exploring (Jimenez-Aleixandre, Rodriguez and Duschl, 2000).
- Empathetic listening is the third type of listening, which is much deeper. Learners may engage with each other's ideas, forgetting about their own ideas and agendas. Scharmer asserts that this type of listening goes beyond mental acquisition of knowledge; it is an emotional response to the interaction. Emotion which is a sub-category of affect is generally classified as irrational and inappropriate at times, but plays a critical role in the meaning making process (Myers, Saunders and Bexell, 2009). According to Myers et al., emotions may stimulate the mind to respond to different types of information based on previous emotional arousal stored in a person's memory.
- The final type of listening is generative listening. A deeper understanding of knowing is attained, having a deeper awareness and attention. In environmental education, a deeper awareness may lead to increased environmental concern (Hawthorne and Alabaster, 1999). The authors add that a deeper awareness improves the individual's internal locus of control (LOC), which consequently transforms their reality. The LOC is essentially "the individual's perception of their ability to bring about change" (Hawthorn and Alabaster, p 27). This is cultivated through continuous dialogue.

Within the different types of listening, the members may shift in and out of seven cognitive spaces as dialogue progresses. The spaces include the following:

Downloading stage happens when we view the world through our habits of thought, we re-enact patterns of the past.

Seeing involves viewing from the outside and seeing with fresh eyes.

Sensing is evident when members of a group start thinking together; they have a shared understanding of how they are connected to the system.

Presencing occurs when individuals let go of their past identity and share a new identity.

Crystallising occurs when individuals clarify their vision and intent for the future.
Co-creating requires members to create prototypes of the concepts they have developed during crystallising. Scharmer defines prototyping as a means to explore the future by doing.
Co-evolving involves performing in new practices. **A**t this stage the group is no longer the same as they were when they started; they have undergone a subtle yet profound change. Scharmer's cognitive spaces offer a very good gauge to measure the progress of dialogue in organisations. These cognitive spaces identified by Scharmer may be adapted to fit within the field of education. These spaces were identified during the Energy Dialogues and are further discussed in Chapter 5.

It is clear that there is no perfect learning environment to educate people on energy use and management. A blend of learning environments is necessary to achieve a deep learning experience. Informal learning systems emphasise that social interaction is a key factor that assists learners in making meaning of their experience. The lens that I used for my study is discussed further in the following section, the theoretical framework, which addresses the different approaches to constructing knowledge within a social learning framework.

2.8. Theoretical frame work

A theoretical framework guided my study and ensured that I stayed focused on answering my research questions. I found an appropriate lens with which to view my findings. My theoretical framework is thus based on social learning (group learning) in relation to situated cognition. In this section I offer justification for my theoretical framework and explore various theories on group learning.

2.8.1 Rationale for theoretical framework

There are strong arguments globally and locally toward framing this study within a social constructivist paradigm. These perspectives help to explain the social system that controls society, for example, the international system is guided by a system of social norms, which determines the lifestyle practices of the collective (Jackson, 2007). These norms are a reflection of the value the collective has placed on ideas about the world. With regards to environmental citizenship, Babcock (2009) asserts that personal and social responsibility for the environment is influenced by the social norms of the individuals' relevant community. We may infer that an individual's attitude is strongly influenced by the attitude of the collective. In order to influence the attitude of the individual, you would need to change the

attitudes of the collective. Lave recommends that learning should be considered as a collective phenomenon. Furthermore, the Energy Dialogues programme takes place inside and outside the classroom. The context wherein learning occurs may determine the learning outcome (Lave, 1996). A learning environment that emotionally arouses a learner by promoting wonder and intrigue may facilitate learning (Myers, Saunders and Bexell, 2009). Adversely, an environment which offers no stimuli may hinder learning. In light of all the factors influencing environmental education in different learning contexts, my study required a lens that examined both the social interactions of learners and the context in which learning occurs.

Situated cognition theory asserts that learning is situated and is part of the product of activity, context, and culture in which it is developed (Lave and Wenger, 1991). Learners are engaged in the educator's demonstration and may learn explicitly in the environment in which the learning occurs (Lave, 1996). Lave suggests that the educator needs to be a competent and experienced co-participant in the learning process. The educator needs to create a space for the learner to be a legitimate participant in the subject being taught. Successfully en-culturing learners into the community of practice requires the learner to imitate the educator in the same way that the apprentice imitates his/her master, following the master's demonstration, and learns the culture of the community through the master (Lave and Wenger, 1991). The learner then acts in accordance with the norms of the culture, developing the language and adopting the belief systems (Brown, Collins and Duguid, 1989).

The learner should be given the authentic tools, activities and opportunities to participate in the learning process and imitate the culture, methods and various other skills of the educators. Brown, Collins and Duguid, (1989) define authentic activities as ordinary practices of the culture. Educators need to en-culture the students by using the relevant tools which will make the learning process real to the student's everyday life, so that they can fully grasp the subject taught. Bowen (2005) recommends authentic science activities outside the classroom. Bowen's experiments with high school students in outdoor activities demonstrated that "engaging students in independent inquiry orientated activities may help them develop the skills used in science communities" (p 127). McGinn and Roth (1999) use the example of HIV/AIDS activists who use scientific approaches to strengthen their arguments. Similar to the activist, learners may impact on the construction and interpretation of scientific knowledge. Falk, Heimlich, and Foutz (2009) reports on a meeting held amongst individuals

from the diverse community of environmental education who were not familiar with each other. The participants shared a common language and culture, so they easily organised themselves into groups and were deeply engaged in conversation within an hour. The participants learned from each other's experiences through sharing ideas. Dialogue is thus encouraged in the community of this practice. The learning outcome is achieved when the learners themselves are energy educators, who engage with energy issues. The following sub-section explores different approaches to group learning.

2.8.2 Group learning

Brodie and Pournara (2005) identified five approaches to doing group work, namely, co-operative, collaborative, socio-cultural, socio-political and situated approaches. Brodie and Pournara developed these approaches within the classroom, whilst my study occurred inside and outside the classroom. My intention was thus to build on their ideas. With the exception of the socio-political approach, my study engaged with all the approaches as they overlap with one another. Slavin (1992) and Webb and Palinscar (1996) argue that collaboration subsumes cooperation. Graesser, Person and Magliano (1995) do not make any distinction between cooperative and collaborative learning, which is not always clear in the literature. (Dillenbourg, 1999). Cooperative and collaborative learning is thus discussed in greater depth below.

The co-operative approach refers to group work, where members are assigned roles to teach each other. According to Feinberg and Leinhardt (2002), the relationship that learners have built amongst themselves prior to a visit will either enable or constrain their conversations. Slavin (1992) asserts that co-operative learning has been very successfully in education, having significant impacts on student achievement. Slavin identifies four major perspectives to attaining cooperative learning, which include motivational, social cohesion, cognitive elaboration and developmental perspectives. These perspectives are discussed below:

- *Motivational Perspectives* value the role of rewards and goal structures in learning. Learners are motivated to work co-operatively to achieve their personal goals.
- *Social Cohesion Perspectives* are based on the learners' sense of social responsibility to help one another. The familiarity of the group members with each other may determine how openly they share their ideas. Social roles have a significant effect on the learner's experience.

- *Cognitive Elaboration Perspectives* are based on the importance of self-regulation. This involves cognitive restructuring and elaboration of information in the mind which is fundamental to development and learning (Piaget, 2003). The learners may recall and explain the material to each other. Members of a group, who are perceived to be knowledgeable, may dominate conversations (Blumenfeld et al., 1996). A study within the classroom context conducted by Brodie and Pournara (2005) has shown that in cases where an 'expert learner' has the role of leading a group, learners may learn the most. The expert learner has the opportunity to think scientifically as he/she asks the questions and does the explaining whilst the other learners listen. On the contrary, an expert learner in an informal learning centre may offer members an opportunity to build on each other's ideas in a joint manner (Leinhardt and Gregg, 2002).
- *Developmental Perspectives* promotes peer collaboration that involves learners assisting each other to solve problems in order to improve their mastery of critical concepts.

  This perspective is based on Vygotsky's theory on development and learning. Vygotsky identified a potential for learning beyond a learner's expected capacity to learn. This potential is reached through problem solving in collaboration with more capable peers, and consequently the learner may reach their potential development, which is measured by the degree that an individual grasps complex concepts with the assistance of the individual's society/community. Development without instruction or the assistance of the communities is referred to the actual development. The intermediate gap between actual and potential development is termed by Vygotsky as the zone of proximal development (Vygotsky 1978). The zone of proximal development is the area in which instruction and motivation is vital for learning. The limits on learning are influenced on the psychology of the group. If the group does not stimulate the learner, development will occur very slowly or not at all.

According to Slavin (1992), group rewards and individual accountability are the most effective approach to ensuring co-operative learning. Slavin makes a strong argument regarding learners' willingness to help each other in group work when motivated by extrinsic rewards. He uses a number of scenarios to demonstrate the effectiveness of extrinsic rewards in learning. Babcock (2009) confirms "rewarding people for positive behaviour may secure a norm or behavioural changes" (p 162).

The collaborative approach is a task-centred approach which involves tasks that cannot be learned by a single learner alone. Members of the group work together, to find solutions to the problems of the tasks (Dillenbourg, 1999). Collaborative learning is identified as a key strategy to learn how to solve problems. Collaborative learning has been identified as a strategy to induce critical thinking and improve problem solving skills (Dillenbourg, 1999; Piccoli, Ahmad, Ives, 2001; Ocker and Yaverbaum, 2001). Dillenbourg asserts that interaction amongst learners may increase the cognitive load of each learner, conversely, the division of labour may reduce cognitive load as learners regulate each other's learning processes. Peer collaboration as termed by Van Zee et al. (2001), is a successful approach to promoting dialogue as it involves learner enquiry as well as give the learners tasks that encourage social engagement for learning with minimal presence of the instructor. The study conducted by Van Zee et al. demonstrated that guided discussions allow learners to converse thoughtfully by explaining their ideas. They further assert that as much as educators' questions stimulate thinking in learners, learners' questions may make a significant contribution to knowledge construction. Learners' questions are an indication of critical thinking. The appropriate tasks and activities that students are familiar with are necessary to allow investigation that may result in scientific thinking (Simon and Maloney, 2007). Peer collaborations give learners an opportunity to ask questions and make a significant contribution to their knowledge construction (Brodie and Pournara, 2005).

Collaborative learning has its drawbacks in that learners do not always co-operate, miscommunication may lead to complications, and learners may feel alienated in a group (Blumenfeld et al., 1996). The situation most conducive to collaborative learning occurs when participants share a common ground (Dillenbourg, 1999). Attaining common ground refers to their level of knowledge and their level of status in their communities. The mental capacities of people who share common ground may potentially expand when involved in collaborative activities. Participation and contribution of all members of the group are the main criteria for collaborative learning. Interactions that are characterised as collaborative are generally non- authoritative; negotiation is thus a key feature to ensure that one learner's view is not imposed on another (Dillenbourg, 1999).

The socio-cultural approach includes the interaction of members and the educator investigating ideas together to develop shared meanings. The role of the educator as defined by social cognition is mediation. As a mediator, the educator plays an active role in the

learners' lives by creating tools, activities and space for learning. The educator should provide time for playing that includes reading and writing. Role play may offer learners an experience beyond his/her reality, performing tasks that would be characterised as beyond the expected competency level of the learner, placing the learner in their zone of proximal development (Newman and Holzman, 1993). A study conducted by Herrenkohl and Guerra (1999) reports that the educators role as a mediator in group-learning allows the learners to initiate discussion. Rosenthal and Blankman-Hetrick (2002) advise that learning is not very evident in cases where educators talk too much or too little. When an educator talks too much, the learners are not given an opportunity to construct their own knowledge, the learner may experience, 'information overload'. On the contrary, when an educator talks too little the learner is not given an opportunity to reach a higher level of learning. Rosenthal and Blankman-Hetrick assert that when an educator engages with learners, the engagement may stimulate the learner to identify, analyse, synthesise and examine objects. The educator's role should be limited as discussions within groups are more likely to occur when groups are left alone after instruction. The manner in which the instruction occurs is critical.

The socio-political is an approach where members are explicitly made aware of social issues to critically think of when doing group-work. The socio-political approach was not relevant to my study, as my study is not framed within a critical theorist paradigm. My research does not aim to approve or disprove any theories on learner interaction based on culture, history, gender or religion. The gender of the learners was noted but their responses based on their gender were not critiqued, only their responses and behaviour with regards to their knowledge and concern for the environment.

Finally a situated approach involves creating tasks that encourage members to talk and act within the context in which they are learning, so that they may be better participants in the discourse. The situated approach is based on situated cognition theory that places great emphasis on the activities performed by the learner and suggests that learning occurs in a participation framework (Lave and Wenger, 1991). The participation framework offers learners an opportunity to belong to a community. According to Wenger (2000), there are three modes of belonging in social learning systems: engagement, imagination and alignment. *Engagement* involves interacting with others and our environment. We make meaning of experience through doing things together and helping each other solve problems.

Imagination refers to our ability to portray our identities based on our reflection of our situation and experience of the world. People construct their worlds differently; however, imagination allows us to stretch our minds and offers us an opportunity of sharing a similar meaning of the world with different communities.

In this context, *alignment* would refer to the activities in the classroom in relation to the higher goals of society. For example, highly committed and engaged environmental activists of an environmental movement will take action and bear costs to support a movement (Stern et al., 1999). Classroom activities should thus focus on changing the attitudes and behaviours of the learners so that they may participate in the environmental movement.

These modes of belonging may complement each other and may improve social learning. Imagination offers learners an opportunity to cross boundaries from one community to another, allowing engagement and alignment. Activities should trigger the learners' imagination and allow them to explore different possibilities so that they may understand other points of view and share different perspectives.

Brodie and Pournara's group learning approaches are based on various perspectives within the social constructivist paradigm, including the Vygotskyan socio-cultural theory (co-operative, collaborative and socio-cultural approaches), the feminist critical theory (socio-political approach) and the situated cognition theory (situated learning). Considering that during dialogue, group dynamics change, it is expected that the group learning approaches would change. All other approaches were used in my study. I have used the insights of the socio-political approach to some extent to establish whether the programme is aware and sensitive to differences in cultures, gender and socio-economic statuses. The situated approach was very critical in this study because it engages well with the objectives of environmental education in the 21st century.

As discussed in the review, environmental education should no longer be bound to the classroom, but become community based. Cooperative, socio-cultural and collaborative approaches promote problem-solving skills, which is fundamental in environmental education. The methodology of my research is thus sensitive to the interaction of the learner and his/her environment as these are critical to group learning. This framework offers a rationale for my research design and approach, discussed in the following chapter, the methodology.

3 METHODOLOGY

3.1. Introduction

The research project was designed to capture the social interaction amongst learners during the "Energy Dialogues" programme. The programme included three stages of activities, a single pre-visit, a visit at DEC and three post visit activities. The "Energy Dialogues" is a pilot programme conducted in a non-formal learning environment. This programme has aspects of formal learning. It is structured and aims to address the school Curriculum. The learners were required to follow instructions, fill in worksheets and they were limited to addressing the pre-determined issues.

The unpredictable social setting required frequent refining of the research plan. Three paradigms were considered for the study including positivism, constructivism and social critical theory as classified by Henning, van Rensburg and Smit (2004). The constructivist paradigm was selected based on Popper's (1963) notion of deduction by falsification. Two pilot studies were conducted. A mind-map, which was used as a data collection instrument, was replaced with a survey.

The rationale for the research paradigm and modifications of the research instruments are further discussed in the sections below. Trustworthiness and ethical considerations are also addressed.

3.2. Rationale for research paradigm

The research design has been shaped within a constructivist, interpretive paradigm, which has accommodated the research objectives. The research objective is to discern the meaning learners place on an energy conservation programme. It is conducted in both a classroom and an informal learning centre. The phenomena learners experience in various contexts is dynamic and their realities in different environments constantly change (Gerber, 1996). In this context, exploring alternative constructions of reality is thus more valuable than determining the ultimate truth.

"Truth" is classified as absolute within the positivist paradigm, although in the interpretive paradigm; "scientific methods can only give us an approximation of the truth" (Henning, 2004). The positivists' paradigm about "truth" may have its merits in other disciplines where

the investigator controls the object investigated or where feelings and thinking are not considered in the study. This study is concerned with attitudes of the learners regarding their environment but it has no intention of determining the causal laws that may affect the learners' attitudes. Furthermore, the assumption is made that learning occurs within a socio-cultural context wherein people discover ideas and share meanings of their ideas. According to Henning, positivism does not consider people's knowledge construction or the socio-cultural context wherein learning occurs.

Critical theory, on one hand, may appear to be fitting for my study as the socio-cultural aspects of learning are considered, but on the other hand, the research objective would not be achieved. Within the critical paradigm, pre-existing knowledge of the context informs the focus of the research and the researcher may have a strong political agenda (Henning et al., 2004). Critical theorists aim to deconstruct and reconstruct knowledge. The context of this study is unique, where pre-existing knowledge is limited. My research has no intention of solving problems or changing the learners' reality. It aims to explore the learners' realities. The interpretive constructive paradigm is thus more suitable as it offers a framework for phenomena to be understood. According to Henning, the interpretive constructive paradigm may produce descriptive analysis of the learners' experience.

3.3. Research design

The research design illuminated the social processes that occurred during the dialogues. An in-depth account of the events is reported in this study. The research design involves a mixed research approach; semi-quantitative and qualitative data was collected. A mixed approach was favoured as I wished to unravel the complexity of social phenomena that were unpredictable. Qualitatively, I determined the programme's potential to promote collaborative learning about and to affect the learners' attitude towards sustainable energy use. The semi-quantitative data was collected to improve the rigour of the research.

3.3.1 Rationale for research approach

Four strategies within the interpretive paradigm, including a descriptive case study, grounded theory, ethnography and phenomenology were considered to conduct this study. The setting created was unique and dynamic, and a descriptive case study was thus selected to unravel the complexities of the programme.

Phenomenology was not favoured as it limits the researcher to interviewing people who have experienced the phenomena under study. The researcher analyses the perceptions of the participants without a theoretical framework (Groenewald, 2004). The literature of the study was not exhausted prior to data collection, although a theoretical framework was developed prior to data collection. The research approach could thus not be classified as phenomenology or grounded theory.

This descriptive case study has drawn on various instruments and literature to collect the data. The research was developed through three data collection techniques, a multi-faceted survey, an evaluation sheet and participatory observation. Data from all the techniques were compared to improve rigour. The multi-faceted survey was developed during the research process and the typologies were created from the literature. As a facilitator of the programme, using participatory observation I sampled data throughout the process and I observed all the activities. At the onset of the research, a single post-visit was envisioned, although sampling continued until the dialogue of the learners was concluded and the dialogue of the community started, so three post visits were conducted.

This study focuses strongly on the content of conversations with regards to energy management with lesser emphasis on the learners' social practices. My study could not be classified as ethnographic because ethnography concerns itself with cultural theory whilst this study attempts to explicate cognitive theories. A descriptive case study offers the reader an opportunity to explore various issues that may arise from the Energy Dialogues programme developed by DEC**.**

3.3.2 The sample

DEC elected grade 11 learners to participate in this pilot programme because energy use and management studies forms part of their geography curriculum. For logistical reasons, the students represented were from the Gauteng region. Two schools were selected to pilot the instruments. The pilot schools were used to determine validity of the instruments.

The school chosen to participate in this study was from the southern district. During a briefing meeting with participating schools, the geography teacher of the school selected had shown enthusiasm and interest in the programme. The teacher invited me to the school to meet the learners and offered to assist me with my project. The support of the school was very crucial

as I conducted both pre and post visits. The school was scheduled for a visit to DEC when the instruments had been refined and were ready for data collection.

The school considered is a well-resourced school in the area. It was previously classified as a predominantly white school, but in 1995 the school opened its doors to learners of all races. Today, the majority of the learners are black. Two classes participated, which had 31 learners overall, consisting of both boys and girls. The survey was distributed throughout the class. Each learner contributed to the research. However, only a group of five learners (three girls and two boys) were selected to offer an in depth analysis. A sample of five learners was chosen for two reasons. Firstly, the sample was convenient as the classroom was structured to accommodate groups of five learners. Secondly, as the primary observer, observing a large group offered great challenges during the pilot study. Keeping track of all the learners' responses proved to be difficult and audio devices were limited. A group of five was manageable and directed the study. This group will be referred to as the focus group throughout the report.

The sample chosen is not a reflection of the experience of all the learners on the Energy Dialogues programme. The analysis of this sample addresses some of alternative realities that learners may experience.

3.4. Research Instruments

Multiple realities were attained by using a variety of data and sources to approximate the truth (Henning et al., 2004). I sought to attain approximations of the truth because this research fits within an interpretive constructivist paradigm that informs us that we all view the world differently and that our understanding of the world is constantly changing. Furthermore, learners may only share

The instruments of assessment included a pre-visit activity, observation during the excursion the educators' evaluation sheets of the programme and post-visit group discussions. The assessment instruments were designed to answer the research questions.

3.4.1 Pre-visit mind map

Prior knowledge is a key factor in determining the knowledge that learners construct (Falk and Storksdieck, 2005). To determine the learners' prior knowledge I facilitated and observed a pre-visit activity. At the onset of the activity I offered learners the material and information

on how to create the mind map. They were encouraged to ask strategic questions on how to do the activity but not conceptual questions. As a researcher, I observed the learners whilst they engaged in the activity. My field notes included my responses to the learners' interaction with each other. The audio device ensured that the details of the conversations were recorded.

The objective of the pre-visit activity was to prepare the learners for the visit to DEC. The pre-visit activity involved giving each group a poster with various cuing images of places where energy is used (see Appendix D). The learners were requested to articulate what they already knew about energy use and management. They reported their ideas onto a page in which pre-selected phrases relating to the topic were randomly written. The learners were then requested to add their ideas and thoughts that are associated with the images on a mind map. The activity offered baseline data which informed me about their prior knowledge and alternative conceptions that learners may bring to the programme, as well as their attitudes towards energy use and management.

The mind map activity was developed to address whether the learners' conceptual understanding of a topic improved due to their learning experience at the centre. The idea of using a mind map was inspired by Leinhardt and Gregg, (2002). The authors used pre-post visit webs to report changes in teachers' knowledge to the Birmingham Civil rights movement museum. In their study the post webs showed more detailed information compared to the pre-visit. This indicated that the teachers' knowledge improved significantly after the visit to the museum.

3.4.2 Piloting the mind map

On piloting the mind map activity, I realised that the prompt mind map activity used for the pre-visit gave me limited information on learners' existing knowledge and the mind map was therefore ineffective. The learners only identified various energy sources on the poster. The activity did not give learners an opportunity to engage with the concepts emphasised in the programme. The programme emphasised the importance of energy, sustainable energy use, personal energy audits, carbon footprint and the greenhouse effect. The mind map did, however, highlight one misconception that the learners had; they were confused about the terms "non-renewable" and "renewable" energy resources. Solar energy was categorised as a non-renewable source of energy, whilst coal was identified as a renewable source of energy. Learners were also confusing the terms "renewable" with "recycle". Some learners identified

plastics, tins and paper as renewable sources of energy. The mind map activity gave little indication of the learners' understanding of different concepts and did not inform me of their attitude towards energy use and management. The mind map was intended as a learning and research tool. As a learning tool it failed to create a foundation for knowledge construction and as a research tool it would not have assisted the study to determine whether the programme influenced the learners' attitudes towards sustainable energy use and management.

The mind map was thus an invalid instrument. A completely different instrument was created to answer the research questions. The new instrument gave significantly more information, which was an improvement to the mind map. The instrument created was a multi-faceted survey. The survey was a research tool as well as a social activity that engaged learners to learn about each other and inform each other on various phenomena associated with the topic energy use and management.

3.4.3 The multi-faceted survey

The multi-faceted survey was originally a game, created by DEC. The game was created for a learner's workshop on climate change. The learners were requested to ask each other questions and explain their answers. I identified this game as a potential research tool to measure social collaborative learning and to determine people's perceptions and conceptions of a topic. I have called it a multi-faceted survey because it may serve many purposes in research. It has the characteristics of both a questionnaire and interview.

The survey did not have a typical questionnaire layout as most surveys. The layout was in a grid format and the ordering of questions is random (see Appendix E). The grid format of questions allowed the learners to start with any question. The grid was made of twenty four open ended questions. There was no limit on the time spent on each question. The learners were given an opportunity to discuss their experiences and their assumptions on each question without the interference of the teachers or myself. The survey had aspects of an interview in that "respondents were encouraged to develop their own ideas", (Opie, 2004, p 111). The survey required no interpersonal skills from me; I did not have to ask the questions, prompt or probe the learners. Learners were required to find friends in their groups who could answer the questions on the grid. The groups were encouraged to ask each other to explain phenomena or their experience, depending on the context of the question. All knowledgeable learners who could answer the questions had to initial their names next to the question they

answered. The learners probed each other for explanations. The responses were verbally recorded using an audio-tape. The responses from this activity produced semi-quantitative and qualitative data. The semi quantitative data refers to the number of learners who initialled the survey, claiming to know the answer to each question respectively, whilst the qualitative data refers to the responses and explanations of each learner.

The survey was developed to address various themes, which include the learners' behaviour towards the environment, their knowledge on alternative and sustainable use of energy, their knowledge on energy management and their awareness of the consequences of poor energy management. The categories chosen were based on the literature review on environmental education and energy use and management. It was important to determine both the learners' knowledge and lack of knowledge on the topic. The questions thus ranged from simple based questions on learners' everyday activity to difficult ones, which included their understanding of various concepts of environment with regards to energy use and management.

3.4.4 Participant observer

Using field notes and a high quality audio device, I was responsible for most of the data collection during the excursion. The teachers who had accompanied the learners observed the social interaction of the learners. The field notes and audio recordings ensured that I was not reliant on non-response, lack of interested participants and easily distracted participants.
My observation recorded the learners' attitude and actions (Opie, 2004). Whilst engaged in a social activity, they were not aware of their attitude and actions; their attention was focused on the activity, but rarely on their own demeanour. I recorded the events while they happened (Golafshani, 2003). Observation was more applicable to my research as I determined:

- the concepts of energy use and management explored;
- the group dynamics;
- the learners engagement with the exhibits and activities;
- and whether learners' perceptions on energy use and management had changed.

Field notes chosen as a structured observation schedule run the risk of over-simplifying the phenomena. However, field notes offered more richness and depth, which cannot be captured by an observation schedule. The case study, 'Verbal interactions in CASE lessons in Malawi' (Mbano, 2002), which was directed by systematic observation, demonstrates the disadvantages of using a very structured schedule. Mbano's study was focused on the verbal interactions of a cognitive nature between the pupils and teacher. It did not consider the

intention of interaction and the aspects of the classroom environment because of the limitations created by the pre-determined categories developed from the theoretical framework. This information may have given Mbano's study more depth. Understanding the effects of the informal learning environment on learner attitude towards sustainable energy principles and approaches, and identifying social interactions that promotes learning are the focal points of the study. In response to the lessons learnt from the study of Mbano (2002), my observations have not been guided by a schedule.

3.4.5 Evaluation sheets

Evaluation sheets were distributed to fifteen teachers from different schools at the end of the visit by DEC. The evaluation sheets completed by the observing teachers did not form a critical part of this research, but have been a useful evaluation and triangulation tool. The responses from the teachers observation recorded on the evaluation sheets have been used to back up my claims on the mediation tools and the learners' interaction during the excursion. The layout of the evaluation sheet may be found in Appendix F.

3.5. Data collection

Data collection included subjective accounts and perceptions of the learners to determine how they constructed their knowledge (Opie, 2004). As recommended by Denscombe (2007), I attended all the programme activities and became part of the nature of things; it gave me a full understanding of the social interaction which shaped the learning process. Data was collected over four months. Table 1 tabulates the data collection process, including timeline and the learning environment.

Table 1: Data Collection process

Date	Environment	Activity	Instruments
25 October 2010	Pre visit activity in the classroom	Multi-faceted survey	Survey, observation, audio device
9 November 2010	Excursion at Delta	Scavenger hunt Energy audit	Observation, evaluation sheets, audio device
24 November 2010	Post visit 1 in the classroom	Multi-faceted survey	Observation
8 February 2011	Post visit 2 in the classroom	Learners action plan, discussion with DEC officers	Observation, audio device
17 February 2011	Post visit 3 in the classroom	Learners preparation for campaign exhibition	Observation, audio device
2 March 2011	Campaign exhibition at Delta	Learners presentation	Observation, audio device

3.5.1 The pre-visit

The pre-visit activity was conducted during a classroom lesson, which lasted 45 minutes. The learners were briefed on the research objectives. All the grade 11 learners volunteered to be part of the research. They completed the multi-faceted survey in groups, which offered semi-quantitative data. The focus group conversations after the survey were observed and recorded. I guided the focus group meeting to ensure that I had a reasonable understanding of the learners' conceptual knowledge on the topic, and addressed the questions on the survey that required learners to explain the concepts climate change, greenhouse effect and global warming. Learners who had initialled their names on the survey were given an opportunity to explain these key concepts.

3.5.2 The Excursion

The excursion occurred two weeks after the pre-visit. An audio-device and field notes were used to record the learners' experience. Although the audio device was of high quality, the rooms of the centre were small and the noise of different group conversations occurring simultaneously caused a disturbance to the focus group conversations during the energy audit activity. According to Allen (2002), learning centres are typically noisy and often a challenge to record conversations. The noise was filtered out using Virtual DJ software, and I transcribed the audible conversations.

3.5.3 Post visits

The post visit was focussed on answering the third research question, which is concerned with the learners' attitude towards the environment. The post-visit did not follow the same procedure as the pre-visit, in that I conducted three post visits instead of one. The activities of the post visit were not pre-determined; the activities were directed by the learners' ideas. I continued the role of a participant observer.

The first post-visit occurred two weeks after the excursion. This visit was not very successful. Two major problems arose. Firstly, the number of learners who participated was halved, as the learners had completed an examination and had no extrinsic motivation to participate. Sixteen learners were available to redo the multi-faceted survey while the other fifteen learners were otherwise occupied. The objective of this exercise was to measure the conceptual improvements as a result of the informal learning intervention. The data collected could not be compared with the pre-visit data. It is important to note that the learners

completed this activity in half the time than the pre-visit. Secondly, the audio device that was used during the previous activities was not in working order, so field notes were used to record the conversations. The field notes were constructed in point form, and only key points were noted.

The second post-visit was conducted two months after the first post-visit guided by the staff of DEC. All thirty-one learners attended the meeting, which was very informal. DEC offered the learners instruction on the rules of the campaign and ideas on how to create an action plan for their campaign, and the learners shared their campaign project plan with the DEC officers. I observed the interaction of the learners with the DEC officers, paying special attention to the responses of the focus group.

The final post-visit was conducted a week after the second post-visit. I offered the focus group copies of my transcriptions of the pre-visit activity and the excursion along with my commentary. The learners were requested to validate my observations and readdress some of the issues discussed during the excursion. This activity ensured that the participants received feedback. During this visit, sixteen learners, including the focus group, had commenced with preparations for the Energy Dialogues campaign. The teacher provided the intellectual framework of assigning roles, collating learners' ideas and presenting learners' ideas in a PowerPoint presentation while I observed the preparation process.

The energy dialogue expo took place at DEC. Five learners from each participating school were invited to exhibit their campaign. Three learners of the focus group attended the expo. I recorded the learners' presentations with the audio device.

3.6. Trustworthiness of the research

This section examines the methodology approach to ensure that this study is of good quality and significant in the human sciences. This study is an evaluation of the Energy Dialogues programme and the criteria for evaluation which include validity and reliability may not fit the methodology of the study (Scaife, 2004). The criteria for trustworthiness may successfully assess the quality of a qualitative research. According to Seale (1999), trustworthiness is a relative term and is thus negotiable as there are various interpretations of trustworthiness. Guba and Lincoln (1989) recommend that transferability and confirmability may be used as

criteria for trustworthiness. Although validity and reliability have not been disregarded, they have, however, been redefined.

3.6.1 Confirmability

Non-participant observers used evaluation sheets to ensure that observer bias was controlled. Unlike Mbano (2002), an inter-observer agreement co-efficient was not determined because my observations were not guided by a structured observation schedule. Transcriptions of my observations were given to the participants for confirmability. The participants critically examined my interpretation of their experience. The necessary changes were made and are discussed in the analysis.

3.6.2 Transferability

The multifaceted survey was originally used for a climate change workshop. The same instrument was used in this study to determine learners' prior knowledge and behaviour. Two Marang fellows from the University of Witwatersrand and an education officer at DEC were consulted to comment on the transferability of the survey. The only change made was the arrangement of questions. Easier questions and statements were placed at the top of the survey, whilst the more difficult ones were at the bottom.

3.6.3 Ethical considerations

The ultimate goal of this research is to add value to human sciences. The disregard of ethical issues will be an injustice to the research. Ethical issues in this context refer to respecting participants' rights to confidentiality, freedom of choice, to be treated fairly and equally in my research.

3.6.4 Right to be treated fairly and equally

Application to do research on humans was made to the Human Research Ethics Committee (HREC, non-medical) at the University of the Witwatersrand. The HREC further ensured that the procedures of the research uphold the ethical code of research. This code includes '*the application of moral principles to prevent harming or wrongdoing others, to promote good, to be respectful and fair.*'(Sikes, 2004, p 25).

The dialogue activities were created by the staff members of DEC. DEC allowed me onto their premises to understand how Energy Dialogues may be used in education to improve

learners' understanding of concepts. DEC has been given an opportunity to critique my analysis of the programme.

3.6.5 Addressing freedom of choice

Consent forms were handed to all participants. Learners were informed of the research and the procedures. Permission for observation and audio-recording was requested. Participants were free to withdraw at any time during the study. The learners form part of the greater Gauteng Department of Education. Permission from the GDE was requested and subsequently approved.

3.6.6 Participants' rights to confidentiality

All information collected in my study has been kept confidential and used only for the purpose of this study. No names or personal details of participants are revealed in this report. Raw data has been safely stored. I ensured that the participants were given feedback when the research was complete. Furthermore, appreciation for participating in my study has been verbally expressed.

The participants of the study have played a vital role in determining the research design. The unpredictability of the programme was accommodated by the flexibility and adaptability of a case study approach (Roberts, 1996). The following chapter unfolds the events of the case.

4 UNFOLDING THE EVENTS

The key findings of the Energy Dialogues Programme are presented in this chapter. Typological and narrative analysis approaches have been used to determine the impact of the programme on the learners' attitudes towards sustainable energy principles and approaches.

4.1. Data analysis

The data analysis includes two typological analyses, an environmental cluster analysis and a talking science cluster analysis. The environmental cluster analysis is an adaptation of the Rokicka and Stomczynska's (2002) "pro-environmental five cluster analysis". The visitor talking science categories has been developed by Allen (2002).

4.1.1 Environmental cluster analysis

The realities of five learners are uncovered in this chapter. Prior knowledge and the concern for the environment of each learner of the focus group are explored. The environmental attitudes of learners before and after the Energy Dialogues activities is analysed using an adaptation of the "pro-environmental five cluster analysis" devised by Rokicka and Stomczynska (2002). The clusters address the cognitive, affective and behavioural components that define people's attitudes towards the environment and may effectively be used to determine the change of the learners' attitude towards sustainable energy use.

Cluster 1: An *un-crystallised* attitude is an attitude that lacks both knowledge and emotion about the environment. A learner having an un-crystallised attitude would offer invalid information. The learner may not show any interest in environmental issues.

Cluster 2: An *emotional* attitude refers to an attitude that is based on the emotional orientation of the individual but the level of knowledge about a problem is very low. The learners' attitude is mostly influenced by personality variables, not their environmental knowledge. The economic orientation of the learner or their sense of personal and social responsibility guides their pro-environmental attitude.

Cluster 3: *Emotional perceptual* attitudes are held by individuals who have strong, emotionally charged attitudes towards the environment, with a slightly weaker cognitive component. The learner's environmental concern is mainly influenced by their personality variables, with less accredited to their environmental knowledge.

Cluster 4: A *perceptual emotional* attitude involves a well-developed cognitive component with a strong emotionally charged attitude, although this is not evident in behaviour. The

learner may express their intention to live a sustainable lifestyle but may fail to change their behaviour due to external factors.

Cluster 5: A *fully developed attitude* refers to an attitude that is a result of well-developed cognitive and emotional assessment components evident in the behaviour of the individual. The learner lives an environmentally friendly and sustainable lifestyle as a result of their environmental knowledge and concern.

I propose a sixth cluster, *perceptual attitude*. A learner having a perceptual attitude may have a well-developed cognitive component but has very little or no concern for the environment. This is in agreement with Dias, Mattos and Balestieri (2004) that people's environmental knowledge of the efficient use of energy does not equate to a high environmental concern.

The term pro-environmental is not well defined by Rokicka and Stomczynska (2002). The prefix, pro in pro-environmental would suggest that one is in favour of environment. An individual having an un-crystallised attitude is not in favour of the environment and cannot be pro-environment. In this study we will refer to the clusters as environmental attitudes. Table 2 summarises the environmental attitude categories, including the degree of environmental awareness, concern and pro-environmental behaviour. The learners' pro-environmental behaviour will not be assessed as we have established in literature that an individual may have a pro-environmental behaviour but this may not be a consequence of the individual's environment concern (Dobson, 2003). As we may recall, a willingness to learn and to act is an indication of a pro-environmental attitude (Hawthorne and Alabaster, 1999). A fully developed environmental attitude is the only category that involves an active environmental behaviour which is influenced by the learners' environmental concern.

Table 2: Categories of environmental attitudes

Environmental attitudes	**Environmental Awareness**	**Emotional orientation**	**Pro-environment Behaviour**
Un-crystallised	Weak	Low	Passive/active
Emotional	Weak	High	Passive/active
Emotional Perceptual	Medium	High	Passive/active
Perceptual	Strong	Low	Passive/active
Perceptual Emotional	Strong	High	Passive/active
Fully developed	Strong	High	Active

4.1.2 Narrative analysis

The excursion to DEC is presented in a narrative format. This narrative may be classified as literary journalism which has been defined by Zeller (1995). The analysis of the observations is represented in scenic episodes, i.e. the activities are reported in the sequence as they occurred. I opted for a third person's point of view as I was a participant observer. Narrative analysis inquires the unique characteristics of human existence and describes experience (Polkinghorne, 19995). Narratives are commonly used in indigenous knowledge systems to communicate all kinds of information. According to Cajete (2008), indigenous science includes everything from metaphysics to philosophy to answer many questions about our natural reality. The analysis of the narratives provides a closer, deeper examination of the data in Chapter 5. The learners' conversations at DEC are analysed using categories of talking science in informal learning centres as developed by Allen (2002), which are discussed below.

4.1.3 Talking science in informal learning environments

'Talking science' in informal learning centres is a common occurrence (Allen, 2002). Various types of talking may occur in science learning environments. In 2002, a study on learners' conversations while visiting an Exploratorium exhibition was conducted by Allen, the purpose of which was to determine what visitors learn. Allen identified 5 categories of visitor talk in learning centres, namely, perceptual talk, conceptual talk, connecting talk, strategic talk and affective talk. Allen measured the frequency using a coding system to determine what knowledge was constructed by the visitor. According to Packer (2006), visitors are always learning in learning centres, so for this reason the visitor will be classified as a learner. Allen's categories will be discussed in more detail as they are relevant to the analysis of my study.

Perceptual talk refers to talk where learners share their observations of exhibits. Literature reveals that perceptual talk, which includes identifying and classifying objects are the most common manner of talking in informal learning centres (Feinberg and Leinhart, 2002; Allen, 2002; Leinhardt and Gregg, 2002). Perceptual talk is the shallowest form of engagement, as it occurs when the learner has no or little knowledge on the subject content. The learner cannot make inferences on what they cannot understand.

Conceptual talk refers to the learner's interpretation of the visit. Conceptual talk as termed by Allen (2002) has been identified as a major category associated with scientific thinking in a science centre. Conceptual talk involves making claims/hypotheses and making inferences based on the experience the learner has within a physical and social context. The learner does not only identify objects but examines and makes inferences about the phenomenon in which the object occurs. Conceptual talk reflects the learning which is expected in school settings that can be assessed by the schools assessment standards. Conceptual talk is generally brief and not very frequent. During a learner's visit to a science centre, the learner experiences small and subtle changes in their understanding of a concept (Anderson et al., 2000). Anderson et al. further adds that although the activities and demonstrations have a minor effect on understanding change, they have a strong potential that leads to conceptual change. The frequency of conceptual talk in Allen's study is unusually high.

Connecting talk involves talk where the learner relates an exhibit to previous knowledge. Connecting talk includes phrases like 'It looks like a….' Connecting talk indicates that learners are constructing knowledge based on previous knowledge. Learners with prior knowledge or experience relevant to a learning programme are more likely to engage with the subject content on a deeper level. A study by Abu-Shumays and Leinhardt (2002) shows that a more complex level of meaning construction was evident when learners engaged with exhibits they were familiar with. They wouldn't only identify objects but would explain and make sense of their experience. Learners having greater knowledge on a subject may be inclined to explain considerably more than those learners with less knowledge. Feinberg and Leinhardt, (2002) assert that particular features in an exhibit may trigger previous knowledge which allows the learner to examine an exhibit more critically and talk expansively about the topic.

Inter-exhibit connection refers to the learners' ability to find links between exhibits. Allen argues that poor inter-exhibit connecting talk may be a result of poor exhibition designs that are ambiguous, making it difficult for the learner to recognise the links. Exhibition experiences may make a significant impression on the learner that may be stored in the memory of the learner and later consolidated with new experiences. The ultimate goal of the informal learning centre is to maximise the quality of learning, therefore curators are encouraged to create spaces and design authentic activities and exhibits that the learner can relate to (Falk et al., 2002).

Strategic talk involves an explanation on how to use the exhibits. Strategic talk is a measure of the learners' strategic knowledge. It includes phrases like 'you have to press the red button'. Exhibits may be static or include hands-on elements. Hands-on activities, including use of worksheets may limit learning talk as the interaction with exhibits do not give the learner time to reflect on and discuss the experience. Strategic talk or lack thereof informs curators the effect of the activities/exhibition.

Affective talk refers to expressions of the learners experience or feeling of the exhibit. Affective talk includes phrases like, 'cool', 'I don't like it'. Affective talk thus gives an indication of impact of an exhibition on the learner. Expressions of positive or negative feelings thus influence the learners' interest and value in the subject. "Motivation for learning in informal settings is usually intrinsic" (Packer, 2006, p332). Intrinsic motivation is defined as an incentive to do a task for personal pleasure and not external rewards. The intense aesthetic experiences that learners get from attractive objects motivate them to learn. Affective talk in environmental learning centres is an indication of the learners' attitude towards conservation. The quality of the learning experience will thus depend on the impression that the physical setting creates on the learner. Different physical settings evoke feelings and experiences at various levels (Falk and Dierking, 2002).

Table 3 summarises the findings of the frequency of visitor talk of the study conducted by Allen (2002). According to Allen, the high frequency in conceptual talk was probably due to hands-on exhibits which offer visitors an opportunity to reason, predict and self-reflect. A high frequency in affective talk in Allen's study was due to unusual behaviour of live animals and graphic displays of dead animals. Allen proposes three reasons for a low frequency of connective talk:

- the exhibition may have been poorly designed and failed to highlight the links of different exhibits;
- visitors may not have explicitly voiced the connections;
- the coders could not differentiate between inter-exhibit connections and connections of prior knowledge.

Strategic talk in Allen's study reported the lowest frequency. The reason for this may be that the hands-on elements of the study were not very technical in nature. They included headphones, maps and door panels which could be opened to reveal the anatomy of a frog.

Table 3: Categories of visitor talk

Types of talk	Definition	Example, context	Frequency
Perceptual talk	Share observation of exhibits, shallow form of engagement	Identify, classifying objects e.g. That is a solar panel	High, commonest
Conceptual talk	Learners interpretation	Claims and inferences e.g. This car is thus more efficient	High
Connecting talk	Associating an exhibit with previous knowledge or other exhibits	It looks like a We have one at home	Low
Strategic talk	How to use exhibits	Press this button	Lowest
Affective talk	Expressions of feeling	I don't like it, Wow!	High

The frequency of learner talk in Allen's study has been compared to the frequency of my study in section 4.3.5. The following section summarises the learners' individual responses of the focus group to the multifaceted survey. The summary gives an indication of their personality variables and environmental knowledge.

4.2. Learners of the focus group

Samu, Kabelo, Mara, Sue and Tumelo, along with 26 of their class mates, volunteered to be part of the Energy Dialogues programme. The learners were black South African students. Most learners use public transport to school. The focus group consisted of two boys and three girls, aged between 15-18 years.

Two weeks before the excursion, the learners completed the multifaceted survey during the geography period. The analysis of the survey is presented in Chapter 5. It probed learners' ideas on sustainable energy principles and approaches. This activity occurred a month after formal instruction on the topic. The environmental knowledge and personal norms of each member of the group are reported in this section.

Kabelo – Perceptual environmental attitude

Kabelo did not live far from school so he walked to school. This behaviour was not necessarily a consequence of the learner's environmental attitude; it may simply have been convenient for him to walk to school. Kabelo claimed to recycle metal. He collected cans for a lady who sells it to the recycling company and he assisted his grandmother with gardening. Kabelo commented that they would like to recycle paper but cannot because they do not have transport

to move the recycled goods. Kabelo's comment is consistent with Chen and Chai's (2010) study in that his behaviour is strongly influenced by external factors.

Kabelo was the most knowledgeable of the group and he shared his knowledge freely with the other learners. His claims were well backed up with previous learning experiences that the other members of the group could relate to. Kabelo was the only member of the group who knew which natural resource is used to make plastic. He explained *"it's when they make coal and all that, whatever is left over is used for plastic."* Mara was not satisfied with his explanation. After he explained, she still wanted to know which natural resource is used to make plastic. Kabelo elaborated, "*When they make electricity, whatever is left over they use it to make"* Samu was amazed, exclaiming *"Plastic! Hau!"* Kabelo backed his knowledge up by reminding them of a video that they had seen in class. He added "*the reason that we can't get rid of it, because when you burn plastic it gets black, because it comes from oil.*" His ideas were not scientifically sound, but he had some idea of the process used in making plastic.

Kabelo's explanations were often arrogant. When Samu could not define the sustainable use of natural resources, Kabelo explained it to her with irritation in his voice, "*it is maintenance of possible material that can run out or dismantle*". Although Kabelo appeared arrogant, his knowledge was valuable to the group. A compost bin was not general knowledge; the others assumed that it was the same as a rubbish bin. Kabelo corrected them and explained "*it is old food that you throw in your garden."* Kabelo had a fairly good understanding of the consequences of poor practices of energy use. During a discussion on global warming, Kabelo's interpretation of global warming was as follows:
'*Before we created all these machines and all that, the amount of carbon and all those greenhouse gases were released, the Earth was able to recover that amount. So then, it had a standard temperature or something, after they started pumping all those greenhouse gases, all the sun's heat that gets trapped here and increases the average temperature of the planet."* He further added, '*the greenhouse effect is a reflection, the sun brings in the heat into the Earth's atmosphere, and during the night when it's supposed to go out, it doesn't, it bounces back because of the clouds*".

Kabelo was the only member of the group that was aware of the global energy management systems that are in place. He was aware of a critical global management system, the Kyoto

protocol and local management systems, recycling. The learner made very little effort to promote these systems. The learner argues that external factors hinder him from recycling.
He explained the Kyoto Protocol to the group, "*It's a place to decrease the carbon dioxide in a country, really that's all I know*". When probed by Samu, Kabelo responded "I*t is something to do with the countries, they had to sign up, it is a group of people that is fighting global warming, the top nations of the world, they are. …..It's a legislation that says they are limiting the amount of carbon emissions that each country that emits a year, to slow down the process of global warming.*" This explanation was the only one offered by the group. The others did not show any signs of knowing any differently and only listened attentively.

The learner was classified as having a perceptual environmental attitude at this stage. There was, however, reasonable doubt as to whether the learner showed any concern for the environment. The learner's belief and values regarding the environment were not well expressed during the pre-visit activity. The study of this learner highlights the limitation of Rockika's and Stomczynska (2002) environmental attitude cluster analysis. The model does not include the probability of a learner having a developed cognitive component, and no emotional component. The learner raised strong arguments that were well backed up. This learner is an example of a well-informed individual, who does not necessarily feel the need to act positively towards the environment. A sensitive, personal and social responsibility was not detected in the learner's responses.

Tumelo – Perceptual environmental attitude
Tumelo occasionally shared his ideas. He claimed that he recycled paper using municipality facilities. This behaviour is not necessarily a condition of his attitude towards sustainable energy use. The learner may possibly recycle because it is convenient or is a reflection of the normal behaviour of people in his community.
His definition of global warming was as follows: "*it is the warming of the globe, the greenhouse gas is the cause of it, ice-caps melt. And all the gases they trap some of the heat and dust and soot*". He would often back up Kabelo's claims. During the discussion on the natural resources used to make plastic, Tumelo agreed with Kabelo and added "*you can burn plastic but you gonna leave a shred of it, you can't decompose it, it can't be a fertilizer*". He spoke with conviction and the other learners paid attention to him.
Tumelo contributed very little to the discussion, although when he contributed, he offered valid information and may thus not be classified as having an un-crystallised attitude. Based

on his response, the cognitive component of Tumelo's attitude was much stronger than his emotional component of his environmental attitude.

Mara - Emotional-perceptual environmental attitude

Mara had no problem expressing her views, and came across as very opinionated. She had a strong sense of personal and social responsibility towards the environment. Mara's attitude toward the environment was expressed during a discussion on her environmental campaign. She strongly asserted, "*we need to start teaching the students here at school to actually know the meaning of conservation and actually looking at the environment and not just throwing papers around, making the effort of picking the papers and putting it into the rubbish bin.*" One of the other learners argued that recycling is expensive, because they need the drums for the paper. Mara did not listen to their argument and continued saying "*We have to start with us as geography students, everywhere I go I always tell my mom and friends that they should not pollute in front of me, some of the people in this class know it, I actually show it in my face, in my emotions and my posture, that says' do not do this. I always emphasise this to everybody that I know that don't pollute, even if people find me irritating*". She spoke passionately about the environment.

Her contribution to the group was limited as she could not convince the other learners with her explanations. Her claims were unwarranted and she could not back them up. She appeared to have some idea of the concepts discussed but could not convince the group, particularly Kabelo. During a discussion on carbon footprints, she claimed that she measures her carbon footprint. Kabelo looked at her sceptically and told her that she was lying, but Mara explained that an expert does it at her home. Kabelo made Mara's claim sound ridiculous by asking her "*Does the expert sleep at your house*?" Mara responded with irritation in her voice "*No, it's like they calculate how much energy you use, the square of your house, the car that you use*". Kabelo continued to probe, "*Do they calculate everything she uses, her car and her cell phone?"* Mara confirmed and added 'my *mother's friend does it'*. Kabelo was still not convinced by Mara's claim and added '*but they would have to be with you all the time*." Mara further weakened her claim regarding her carbon footprint, when she enquired about carbon emissions. Kabelo criticised her and said "*but you said that they calculate carbon what-what emissions at your house, you were lying neh?"* Mara argued, "*No I'm not!"* Kabelo continued confronting her saying, "If *you don't know what carbon*

emissions are, then you were lying". Mara responded that she was not and added "*I know what releases carbon emissions",* but did not explain or give examples to back up her claim.

Mara's explanations of climate change, global warming and the greenhouse effect were unclear as she failed to use points of reference. The learner linked the phenomena but made no reference to the each phenomenon respectively. Her explanations of the phenomena were as follows, "*we have gases that go into the air, when the sun rays comes into the Earth, they reflected off the Earth, they stay inside the sphere, then it makes the area they live in harder. It comes in and doesn't go out. It could also be due to the greenhouse gases they emitted into the atmosphere, it results in heat being trapped and absorbed, thus heating the poles and all our ice-caps, this ice-caps create a climate change within our whole atmosphere, that results in drought in certain areas and raise in the water levels in certain areas*". Mara's fragmented interpretation about the causes and consequences of the phenomenon is a reflection of her human perception of physical events (Lewis and Linn, 1994). Lewis and Linn report that the learner's perception of physical events is informed by intuitive conceptions in response to everyday experience. The learner had a number of ideas but struggled to connect the ideas and create a holistic understanding.

Mara's attitude may be classified as emotional perceptual. The affective component of her attitude was much stronger than her knowledge on the environment. The learner's attitude appeared irrational at times. Her concern for the environment was not deterred by her socio-economic situation. Whilst other learners were concerned about the cost of recycling, the learner did not identify it as a valid excuse not to care for the environment. The learner's intention to act was influenced by her sense of responsibility to the environment. The learner's irrational attitude made her vulnerable to confrontation in arguments. She failed to convince the other learners, particularly Kabelo. He incessantly questioned her reasoning. The analysis of Mara highlights the importance of a balance between knowledge and emotion in issues relating to the environment. She showed great concern for the environment but lacked the ability to convince the other learners of her beliefs.

Samu - Emotional environmental attitude

Samu uses a bus to school. She was keen to learn but not very knowledgeable. The learner's desire to learn was evident by her frequent questions. She asked questions that were general

knowledge to other learners. The term reusable, which is self-explanatory, was not understood. Kabelo defined a reusable bag to her.

The emotional component of her attitude towards the environment was made apparent when she complained about her efforts to make other learners aware of their environmental campaign. She asserted: "*It's difficult to speak to the students, we want to achieve our goal, the students are hard-headed, and we can't reach them*". The learner's lack of information or social status at school may have limited her ability to convince her fellow learners at school. This activity did not determine the learners' social status at school. We may not know whether the learner failed to promote environmental awareness in her school because she lacks the leadership ability, or whether her competence in the topic was the cause.

Samu was the only learner that confused the phenomena of the depletion of the ozone layer with global warming. Her explanation of the global warming was as follows "*It's because we have an ozone layer, the ozone layer reacts with the O_3 gases, all the carbon dioxide and the greenhouse gases which we have emitted by our man made products and substances, and those substances react with the O_3 gas and that gas reaction creates a blanket-layer which causes the heat to not go out to the atmosphere but reflect back"* Learners confusing the global warming and the greenhouse effect with ozone depletion is a very common problem in schools (Koulaidis & Christidou, 1999; Hansen, 2009; Andersson & Wallin, 2000; Osterlind, 2005; and Daniel, Stanisstreet and Boyes, 2004). According to Koulaidis and Christidou (1999, p 1), 'The greenhouse effect is a scientific phenomenon which involves complex processes.' Properties of incoming radiation, outgoing radiation and a barrier are the various elements that are not clear to learners (Andersson and Wallin, 2000). Andersson et al. further assert that the confusion derives from poor instruction and the concepts may be interpreted differently in different contexts.

Samu may be classified as having an emotional attitude towards the environment. The emotional component of her attitude is clearly demonstrated during her speech to promote environmental awareness at school.

Sue – Uncrystallised environmental attitude

Sue was a relatively quiet girl, who did not actively participate in the pre-visit activity. She made two contributions throughout the discussions. During a discussion on global warming,

Sue commented "*the smoke of burning coal goes to the clouds and gives acid rain"*. She made her second contribution during the discussion on sustainable use of natural resources, adding "*it is about maintaining the environment around, like planting and all that is sustainable environment"*. Sue clearly had very little knowledge on the topic at hand. She was the only learner of the group that did not recycle. She did not use a reusable lunch tin either. She showed no strong emotion concerning the environment. Sue's attitude towards sustainable energy use appears to be un-crystallised.

4.3. Comments on the group dynamic

In order to understand the effect of the Energy Dialogues programme, understanding the group dynamic before the intervention was critical. I analysed the realities of a few learners, each having different perceptions about the environment. There may be multiple realities that I have not identified, although based on the environmental cluster analysis developed by Rokicka and Stomczynska (2002), realities may be classified to simplify analysis. Table 4 summarises the learners' environmental attitudes during the pre-visit activity.

Table 4: Learners attitudes towards sustainable energy use

Learner	Pre-visit	Comment
Kabelo	Perceptual	The learner was knowledgeable, but showed very little sense of social responsibility
Tumelo	Perceptual	The learner was knowledgeable, but showed very little sense of social responsibility
Mara	Emotional-perceptual	The learners concern for the environment was well pronounced, her knowledge on the subject was limited
Samu	Emotional	Samu showed concern for the environment, but had limited knowledge on the topic.
Sue	Un-crystallised	Sue showed very little interest in the topics discussed. The learner also appeared to be misinformed about the topic.

Interestingly, the learners having emotionally based attitudes towards sustainable energy use were female, whilst the learners having perceptually based attitudes were male. This sample is too small to make any generalisations regarding gender and learning, but Ocker and Yaverbaum (2001) confirm "women are less collaborative than men" (p 441). The authors recommend that learners should be trained to work collaboratively; men should be trained to be more sensitive, whilst women should learn to be more assertive.

Apart from Sue, the rest of the group was comfortable to ask questions. Sue's inability to interact may be a result of a number of reasons. There are a range of factors that were not established in this study that may have affected the learner's lack of contribution to the

activity. Her personality and role or status in the group may have hindered her participation. The learner may not be recognised as knowledgeable in the group and consequently her contribution may have been undermined. Scholtz et al. (2008) argues that the less competent learners may feel intimidated by articulate repartee of the more competent learners. The learner may be introverted and struggled to express herself. According to Blumenfeld et al. (1996), the status differences in a group may result in a learner feeling rejected and excluded when they are presumed to be incompetent. In agreement with Dijte (2008), the learner's competence in the language of instruction may have deterred her from contribution to the learning experience. The group dynamic may not have accommodated her learning approach. The learner may have required a highly skilled teacher who has very good pedagogical content knowledge associated with good scientific knowledge to manage and encourage her contribution. The study of this learner indicates that not all learners may benefit from peer group collaborations.

The study confirms that learners having different capabilities may not collaborate successfully (Brodie and Pournara, 2005). High achievers may dominate low achievers in heterogeneous groups (Blumenfeld et al., 1996). Low achievers may feel excluded and fail to contribute. Multiple perspectives may be gained from inter-group dialogue. However, there is a risk that only one perspective may be followed if all the participants have nothing to contribute. Furthermore, a peer group discussion has the disadvantage of an expert learner not having Pedagogical Content Knowledge (PCK) to transform the knowledge so that it is understood and accessible to other learners. Shulman (1986) recognised that both content knowledge and pedagogy are significant knowledge components and thus recommended that a blend of the two categories of knowledge is essential for effective teaching. The expert learner may have the content knowledge but may not know the best representations (analogies, examples, explanations) to formulate the subject to make it comprehensible.

The behaviour of all the learners was not fully observed as this study was limited to their learning experience at school; their attitude cannot be classified beyond a reasonable doubt. The learners in the group were the same age but their attitudes towards the environment were different. The following section explores the learners' experience at DEC.

4.4. Learner experience at DEC

The participating learners attend a school in Vereeniging, South of Johannesburg, about 60 kilometres from DEC. They travelled by bus to the centre. The group settled themselves at DEC but were still very excited. Everybody received a worksheet that they had to fill in while doing the activities.

After a short briefing session, the groups were sent off to various stations with an education officer (EO). Mara, Kabelo, Sue, Samu and Tumelo started in the Energy Room. Four activities including the 'energy scavenger hunt', 'bringing it home', 'everything comes from something' and 'measuring our carbon footprint' was observed and are reported in this section.

Instances of learning talk have been coded 1 to 5. Table 5 shows the categories of the codes. These are highlighted in the findings of the focus group learners experience at DEC. With the assistance of my supervisor Dr. Anthony Lelliott, I improved reliability of the analysis of learner talk through inter-coder reliability. Coding of learner talk is limited to the interaction of the focus group.

Table 5: Learner talk codes

Learning talk	Code
Perceptual talk	1
Conceptual talk	2
Connecting talk	3
Strategic talk	4
Affective talk	5

4.4.1 Energy scavenger hunt

The energy scavenger hunt took place in the Energy Room, where the main attraction is a bicycle and a map with flashing lights, highlighting different power stations. The learners were requested to identify the nuclear power station in South Africa. With the exception of Kabelo, the others were unsure. Kabelo answered confidently "Koeberg" (#1, identification). Everyone noted it in their worksheets. They were then requested to find different power stations. When they pressed a button the lights would flash. Samu explained to the others what they had to do (#4, explanation of use). The education officer (EO) left them alone to complete the exercise in their worksheets.

This activity in the Energy Room offered very little opportunity for conceptual talk, very little explaining and discussion occurred. The learners only spoke about the functionality of the map and how it worked. Perceptual talk was also used; learners identified the different power stations (#1, identification). Samu pointed at the hydro storage pump, Mara explained "*it is part of hydroelectricity, water is stored and used when required to generate electricity*" (#2, explanation). The other learners were not convinced and continued with their worksheets.

The next activity dealt with the concept, insulation. This activity offered opportunity for conceptual talk. The concepts "insulation" and "convection" was discussed during this activity. The group discussed different ways of insulating. It was a cold day and they were wearing warm clothing. Samu commented that the clothing that they were wearing insulated them (#3, life connection). The EO asked the learners about insulating buildings. Mara added that they can keep buildings warm using heaters, but Samu disagreed and added that they can use special materials to build (#2, rebuttal). The EO backed Samu's rebuttal and consequently lowered the status of Mara's comment by adding that heaters cannot help if doors are open and the building is made of tin with holes in it. She agreed with Samu that different materials and building techniques may insulate their homes. The exhibits showed different ways of insulating a home. They were requested to identify them. Sue highlighted the geyser blanket (#1, identification). Prior to the visit, members of the focus group did not know what a geyser blanket was. Kabelo explained to the others during the pre-visit activity, "*it's almost like an electric blanket and that it is electric and you plug it in"*. At DEC, the learners saw and touched the geyser blanket and were informed that it keeps the geyser warm. The analogy of a human wearing a blanket was used. The EO explained that it is specially designed for a geyser. The EO was aware of the limitations of the analogy in that the learner may use any blanket to cover the geyser, and explained that they cannot use a normal blanket because it could cause a fire. The learners predicted that they will use less electricity if they use a geyser blanket (# 2, prediction).

Samu pointed out a ceiling insulator (#1, identification). The EO introduced the concept "convection" to the group, making reference to hot and cold air in a room. Samu told her that hot air rises (# 2, explanation). The EO gave her positive feedback and added that heat circulates when there's a ceiling and the heat is consequently prevented from leaving the room. Mara pointed out the window (#1, identification); there was some foam material on the

edge of the window. Mara enquired about it, the EO replied that it was a window insulator and commented that girls always noticed it. She further explained that air can go through a closed window, so the foam ensures that hot air stays in the room when there is insulation on the doors and windows. There was insulation on the door as well. Mara said that they could use sausage dogs (#3, life connection). The EO asked if the carpet they were standing on would help. Mara agreed adding that ceramics are cold, but Samu told her that some ceramics are warm (#3, knowledge connection). The EO agreed but told them that clay ceramics are warm but they can be expensive.

4.4.2 Bringing it home

In the room, there were different types of basins, toilets and showerheads. In this activity they looked at different ways of using water. The activity started with the learners comparing the water usage of two families, where one family wasted water whilst the other family used the water wisely. The learners pointed out poor and good water management shown in the four exhibits with a little help from the education officers (#1, identification). Perceptual talk was the main form of talking. The knowledge learners constructed, with the assistance of the exhibit, were not always based on standard scientific explanation. The dual flush toilet system was an exhibit that was not well understood by the learners. Mara commented that they have one at home but didn't know that the system had two options of flushing. They pressed any button at home. (#3, life connection) Mara made a life connection, having a personal association with the exhibit. The EO explained to the learners that the dual flush system ensures that water is efficiently used.

During a discussion on water consumption, Mara estimated that an individual uses 60 litres of water a day (#3, knowledge connection). The EO informed them that they use 200 litres per person a day and Americans used 500 litres a day. Mara looked very surprised (#5, expression of surprise). The EO further added that they used 8 to 12 litres to flush a toilet. In amazement, the learners exclaimed "aaahs!" and "ooohs!" (#5 expressions of fascination). The EO explained the mechanics of the dual flush system in a way that learners could understand. After the explanation, the learners completed the worksheets individually. Mara wanted to know whether a borehole would be more efficient (#2, critical question). The EO agreed, but commented that it was expensive to sink a borehole. Teaching rational approaches to water conservation was critical.

4.4.3 "Everything comes from something"

At DEC, the exhibit showed models of how cans, paper, plastics and glass are made. The learners were told that they use coal, iron ore, limestone and sinter them to make cans. They all knew that paper comes from wood, which goes through a process to give us paper. They then looked at the exhibit of plastic. The group was shocked that plastic really came from coal. The next presentation was a glass exhibit. The EO asked them "*where does glass come from?"* They read that it comes from sand. Mara's lip dropped and she exclaimed: "*Hau!* (#5, element of surprise). *They use sand, soda ash and lime to make glass".* Allen (2002) defines metacognition as "a reflection of one's own sate of current knowledge"

They then moved into a room to discuss "Everything comes from something" activity. The EO asked the learners about the production of toys, dye and clothing. Tumelo made most of the contributions. Tumelo commented on the energy used in mining and transporting. During a discussion on the production of dye, Tumelo added that they mix chemicals (#2, explanation). The EO informed him that the chemicals come from trees. A t-shirt made in Limpopo was used to emphasise the production process of t-shirts (#3, knowledge connection). Tumelo recommended that they should buy local clothes to save energy. Samu asked whether they should wear clothes from Jet Stores to save energy. They all laughed and then moved on to the next exercise in the worksheet -"Understanding the carbon footprint".

4.4.4 Carbon footprint

The group calculated the carbon emissions transmitted by the staff at DEC. The learners were briefed on the activity and discussed the concept "carbon footprint". The EO explained that the carbon footprint is a measure of how much carbon dioxide we release as individuals. The learners worked out the total carbon footprint for driving of five drivers going to and from work. They received a reading card describing the driver's driving routine every day. They calculated the distance the driver travels per year and then their carbon footprints. The driver that the group analysed was a person called Di. Mara was otherwise occupied and was excused from the discussion. Samu read the label on her car. The label read that the person driving the car lived only two kilometres from work. They calculated the number of kilometres per year and then multiplied that by 0.3, as that is the amount of carbon released per kilometre. They had a small discussion on what this person had to do to reduce her carbon footprint.

Kabelo: I think that this car was better than most cars, because she lives very close to work and I think that she could use public transport or do carpooling, but ….
Tumelo (*interrupted Kabelo*): 2 kilometres bru, isn't far away.
Kabelo: How is she gonna car pool with no people? (#2, critically questions himself)
Samu: What if there are a lot of people that works where she works? They can all use the same car. (#2, back-ups Kabelo's idea)
Tumelo: Why can't she walk two k's? 2 k's is like around the corner
Kabelo: 2 kilometres is a long way, for fat people it's a long way (#2, rebuttal)
Samu: Yes, she can walk
Tumelo: What about the people who can't walk? (#2, critical question)
Samu: Not everybody lives 2 k's away. (#2, rebuttal)
Tumelo: What if it's raining? (#2, critical question)
Kabelo: They can use umbrellas.
Tumelo: What if it's like storming? (#2, critical question)
Kabelo: That's drastic, you not gonna have a storm everyday bra. (#2, rebuttal)
Samu: I'm just saying, that those that live in the area could use one car
Kabelo: Why can't they all walk?
Samu: They safe and they get exercise and they save the Earth, yeah!
Kabelo: This way she spends less on petrol (#2, justification)

Conceptual talk was evident in this event. The learners reasoned with themselves as well as with the group members. The group explored and shared ideas, critically questioning each other's ideas. The EO interrupted their discussion and asked them what they need to do next. Kabelo told her that they need to analyse the situation. Kabelo added that they could rectify the problem by changing the way they drive and use car pools (#2, hypothesis). Sue mentioned that they should use hybrid cars but Kabelo thought that they were expensive. The EO informed the learners that if there is more demand the price will come down. She further added that they have the power to change everything; the suppliers will produce environmentally friendly products if there is a demand.

The learners were thus aware of alternative uses of energy for cars. Tumelo wanted to know more about hybrid cars. He shared his ideas about them but thought that they defeated the purpose of saving energy (#3, knowledge connection). He commented that hybrid cars still use electricity from the house, so they were still using electricity (#2, inference). The EO had

some misconceptions about hybrid car. She claimed that the technology is more efficient but was not aware of the false marketing. The hybrid car is advertised as an energy efficient green product. McKay (2009) argues that although hybrid cars offer fuel savings of 20 % it emits 100g per km of CO_2 which is relatively more than the Smart Car that emits 88g per kilometre. He further adds that the second hybrid, the Lexus RX400 H emits 24 g of CO_2 per km more than a fossil-fuelled powered car. Kabelo added that some cars use bio fuels, but the EO replied that they still developing the technology in Europe. The EO started speaking continuously about the cost of all the new technology. Kabelo had his hand up for a long time. He wanted to know what the government was doing to promote alternative energy practices. He asked whether the government subsidised hybrid cars. The learners were not concerned about their responsibility with conserving the environment; mostly it was other people's concern and the government's responsibility.

They discussed ways in which people could reduce their carbon footprint. Kabelo thought that they should drive slowly and change tyres because bad tyres use more petrol. The EO added that they should close the window when driving. The learners shared ideas with one-another. When Sue added "they should scoop out the water that they used when they bathed", Kabelo interrupted saying "they can water the garden with it". (#3 inter- connecting talk). The learners linked ideas discussed in the water room with the carbon footprint activity. Kabelo commented that he did not know that the cell phone charger only takes 40 % of electricity if it is plugged in and not used. All learners agreed that they should not leave the charger on if it's not in use. The EO ended the activity as the time allocated had been used up.

The programme continued with an energy audit activity and an activity exploring the greenhouse effect. These activities were observed but not recorded as they were not the focus of the study.

4.4.5 Learning talk at DEC

Table 6 compares the learner talk of the Energy Dialogues to the visitor talk at a frog exhibition, a study conducted by Allen (2002). The activities that were recorded engaged the learners with various concepts using objects that they were familiar with, which was evident by their conversations. Conceptual, perceptual and connecting talk was the most common type of talks. Conceptual talk was mostly evident in the carbon footprint activity as the learners' shared their understanding and found solutions to the problem. The solutions

offered by the learners indicate that they applied their knowledge to energy use. Compared to Allen's study, the combination of a higher frequency of connecting talk and a lower affective talk may be due to the fact that the learners had covered the topic in class a month prior to their visit to DEC. Furthermore, the activities offered local knowledge which the learners could engage with and make life connections. Strategic talk was limited as there were very few hands-on activities. Although infrequent, affective talk mostly occurred during the bringing it home activity.

Table 6: Energy dialogues learner talk

Learning talk	Code	Total	Energy Dialogues	Allen (2002)
Perceptual talk	1	6	High	Highest
Conceptual talk	2	19	Highest	High
Connecting talk	3	7	High	Low
Strategic talk	4	1	Lowest	Lowest
Affective talk	5	3	Low	High

The learners left DEC with the challenge of creating a campaign to promote sustainable energy use and management in their communities. I continued observing the learners after the excursion to determine the impact of the intervention on their attitudes towards sustainable energy principles and approaches.

4.5. The Energy Dialogues campaign

My observations of the learners in their classroom weeks after their excursion gave me an opportunity to determine the impact of the learning intervention on their knowledge and concern for the environment with regards to energy use and management. The "pro-environmental five cluster analysis" devised by Rokicka and Stomczynska (2002) was adapted and used to determine changes to the learners' environmental attitude as a result of the Energy Dialogues intervention.

After the visit to DEC, the learners had a feedback talk with the teacher and started preparations for their campaign. The EOs of DEC visited the school and encouraged them to participate in the energy campaign. The geography teacher was very involved in the campaign and assigned various roles of the project to the learners. The roles of the campaign included selecting the presenters, the creators of the poster and the designers of the exhibit. The teacher offered the learners assistance with the exhibition and the learner presentations. Three learners, Samu, Tumelo and Mara were required to present the campaign at DEC.

Samu presented the poster, offering ideas on energy conservation, Tumelo presented the school's recycling campaign and Mara presented the exhibit. The other learners were responsible for building an exhibit. Samu and Tumelo assisted the other learners and worked together on their presentations.

Kabelo -Perceptual environmental attitude

We have already established that Kabelo has a perceptual environmental attitude. The key focus of observing Kabelo in the post-visit was to determine whether the intervention developed a concern for the environment. We cannot claim, without a reasonable doubt, that Kabelo's attitude had become fully developed. No strong evidence of the learners' attitude may be presented. Kabelo rarely contributed verbally during the post-visit activities. During the campaign preparations, Kabelo was actively involved with the construction of the exhibit. He assisted with building the bricks, mixing the cement, creating paper mache and painting the finished product. On completion, Kabelo was very impressed with the brick commenting, "*We should start collecting bottles, so that we can build ourselves a home when we 21*". This insert may have no real meaning, the learner may have meant it as a joke or it could indicate that he has taken personal ownership of the idea. The learner may have personally committed himself to the idea of an eco-friendly lifestyle.

Tumelo - Perceptual emotional environmental attitude

Tumelo's attitude is informed by his understanding of the topic, his connection with it and his passion towards sustainable principles and approaches. Tumelo presented the recycling aspect of their campaign. His presentation was well articulated. The learner recognised that many people are ignorant about the environment and on three occasions during his talk, he challenged his audience with questions. His presentation started with the question, "*Have you ever thought about saving the natural resources of planet Earth?"* He explained the importance of recycling by informing the audience that recycling plastic saves energy. He explained, "*Plastic comes from coal. And we know that coal is non-renewable. So instead of burning plastic or throwing it away, we can reuse them, by doing so we are saving energy*". The learner portrays himself as an activist for the environment. Tumelo offered the audience a personal solution to environmental problems. "A personalistic view is a response to perceiving environmental problems as physical that are direct result of individual polluting behaviour and subject to individual control" (Ballantyne and Packer , 1996, p 6). He concluded his presentation saying, *"We realise if we teach others in our school and teach the*

whole world, it will hopefully become a way of living with them. And they can take our recycle project to the whole world because that is our aim to save the world."

At this stage of the programme I concluded that Tumelo's attitude towards the environment was perceptual emotional with great potential to be fully developed. The learner's knowledge of the topic was consistent. This insert indicates that this learner performs well when engaged with a challenge. The group had set a goal and the learner expressed commitment to the campaign. The learner projected an internal locus of control, and a sense of personal and social responsibility to the environment. These personality variables were not detected during the pre-visit; they were only evident during the post-visit. It is safe to say that the programme offered the learner an opportunity to be pro-active about his concern for the environment.

Mara – Perceptual emotional environmental attitude

Mara's attitude had become more perceptive throughout the Energy Dialogues programme. The change in the learner's attitude is evident in her presentation on their eco-exhibit.

At the exhibition at DEC, Mara presented the eco-brick exhibit. The learner offered the audience an appreciation for their innovation by using an holistic approach. She informed her audience about the economic, social and environmental gains of the innovation. However, some of the key concepts of the Energy Dialogues were not well presented. The learner started her presentation stating, *"Our school is concerned about global warming*" and continued "*the numbers of furnaces used in the industrial economic sector are contributing to global warming"*. The link between global warming and carbon emissions was not made. She informed the audience that the eco-brick requires less bricks per square-meter to build a house but requires more cement but she did not identify cement as a major contributor of carbon emissions. A study by Suzuki and Oka (1998) reported that 0.3 tons of CO_2 is produced for every ton of cement produced. Carbon emissions and the greenhouse effect were major themes of the Energy Dialogues but were not discussed in the presentation.

Mara offered her audience a technocratic solution to the environmental problems. "A technocratic view is a response to perceiving environmental problems as an inevitable result of industry and modern lifestyle, to which new technologies are expected to provide a solution" (Ballantyne and Packer, 1996, p 6). This is evident when the learner concluded her presentation saying, "*We have developed an effective solution in the housing sector and employment in South Africa by creating an eco-brick. We feel strongly that our idea can lead*

to better environmental changes in the future". Apart from the omission of carbon emissions in her presentation, Mara's presentation was well articulated. The learner appeared more assertive and offered the audience significant evidence to back up her claims. She appeared to have a better understanding of the environmental problems with regards to energy use.

Samu – Emotional perceptual attitude

Incremental changes in Samu's attitude towards the environment were observed. The learner's knowledge on the topic improved. However, there were instances which indicate that the cognitive component of the learner's attitude is still weaker than the emotional component. During the feedback discussion, Samu highlighted that the programme effectively taught them about saving water and electricity. The importance of water usage was not addressed in the pre-visit activity. However, learners engaged well with the material because it was practical and useful in their daily activities. Samu raised the concern that her parents are not informed and that it is difficult to persuade them to follow energy saving practices. Samu commented "*You can tell me something and when I go home to tell my parents....I had a hard time with my parents with the whole light thing. They did not understand it at first. They think it's just something that happens at school. They didn't want to hear it. I think it's better if we have a meeting here at school so that we can discuss such things. If they hear it from the teacher they'll understand."* This is a reflection of the evolution of science education in the past 40 years. The parents' experience of environmental education is significantly different from the learners. The learners' experience of environmental education is informed by social constructivism where learners have challenged their social practices (Bakobi, Chleshe and Sgazzin, 1999). Environmental education is not bound to the classroom but is community based, whilst the parents' perception of environmental education may be static and contained. This offers a huge barrier to teaching learners the rational use of energy.

Samu's presentation informed people about energy saving practices in their homes. Her focus was on the importance of switching off unused lights. The learner's attitude may still be classified as emotionally based as she struggled to create a strong argument for her campaign. During preparation for the expo, Samu and Tumelo assisted each other with their presentation. Tumelo offered her ideas on how to present, advising her to start with questions. She complained that Tumelo's approach is too formal; she would like her presentation to be cool and simple. This is evident as she said, "*I will be willing to bet everything I have, that*

you would ask yourself, what difference one light bulb will make? But that's just it. One light makes a big difference". The learner offered evidence to her claim but it was not scientifically correct when she added *"They compared the old light bulb which uses twice as much energy as the energy saving light bulb. So if we use the new light bulbs, we cut the energy by half".* The learner made no reference to the type of light bulb. Her evidence would be seen as invalid in a debate.

Similar to Bell (2004), the learner perceives dealing with environmental issues as a duty; this indicates that the learner has politicised view about thinking of environmental issues. This was evident when she asserted, "*Saving the world is not about the big oil companies and their impact. But it is your duty as well".* According to Ballantyne and Packer, a student having a politicised perception views environmental problems as "global issues representing problems of conflicting ideas, interest and choices and values that can be addressed only by a change of lifestyle" (1996, p 6 of 15). The learner's conclusion of her speech confirms her view. She concluded saying, "*Even our president asks us to. By switching off all unused appliances we are saving energy and by saving energy we are saving the world. Our motto is every person's contribution, no matter how small, makes a difference. We need to save energy because saving is a lifestyle."*

Sue- Uncrystallised attitude

Sue's interaction in the post activity was limited. Sue was responsible for decorating a poster. She worked quietly on her own. She did not interact with any of the other learners. With the exception of asking strategic questions about the poster, the learner did not make any verbal contributions. It is unclear whether the experience at DEC had any impact on the learner's attitude. There is no evidence that the learner was emotionally or perceptually affected by the learning intervention. We may thus assume that the learner's attitude remained un-crystallised.

4.6. Summary of findings

It is clear that the programme was very effective. Table 7 summarises the change in the learners' attitudes towards sustainable energy principles and approaches. Mara and Samu in particular drew information/data from the objects in the energy room to develop their understanding of insulation as a concept. Objects that the learners use in everyday life demonstrated the properties of insulation. The clothing they wear, the carpet, buildings,

ceiling insulator, window insulator. Familiar objects as examples to demonstrate the properties of the insulation created building blocks for the learners to construct their own knowledge (Nesher, 1987). In my opinion, the female learners interacted better with this activity. Females are brought up to be homemakers and have a greater interest in the inner working of a house. These learners' intuitive conceptions were exposed during the activity. The EO managed to develop an argument, which was subtle but effective. She did not capitalise on the cognitive conflict by exploring the learners' intuitive conception, yet she successfully lowered the status of the learners' misconceived ideas by using alternative representations.

Samu and Mara's experience is consistent with the science centre exhibition study conducted by Falk and Storksdieck (2005), when the least knowledgeable learners learnt more from the exhibition. Kabelo and Sue showed no change. Tumelo was influenced by the challenge of a campaign, that is, of setting goals which motivates the learner to perform.

Table 7: Learners attitudes towards sustainable energy use

Learner	Pre-visit	Post visit	Comment
Kabelo	Perceptual	Perceptual	No significant change in the learner's attitude was observed
Tumelo	Perceptual	Perceptual emotional	Campaign offered the learner to promote sustainable principles. The learner has great potential to have a fully developed attitude.
Mara	Emotional-perceptual	Perceptual-emotional	The learner's knowledge improved, and she had become more confident on the topic
Samu	Emotional	Emotional-perceptual	The learner's knowledge improved but not enough to affect her internal locus of control.
Sue	Un-crystallised	Un-crystallised	No significant change in the learner's attitude was observed.

The following chapter explores the different situations and interactions which stimulated learning and the learners' attitudinal change.

5 THE ENERGY DIALOGUES LEARNING PROCESS

There was a significant change in the learners' attitudes towards energy use and management. I was intrigued by this and thus followed up with more literature on the topic of social change. Typologies created from the theoretical framework and the research objectives were used to process the data as recommended by Hatch (2002). In this chapter, a critical analysis of the Energy Dialogues programme assesses group learning and the various learning contexts.

5.1. The learning process

I identified the movements of dialogue developed by Scharmer (2007) in my study. All the cognitive spaces identified by Scharmer are discussed in Chapter 2, but were not all relevant to the context of my study. I have adapted Scharmer's model to fit within the scope of my study. The spaces of downloading, seeing, crystallising, co-creating and co-evolving as social processes are discussed below. Sensing and prescencing are not included in my study as they may be viewed as psychological phenomena. Scharmer describes these processes as deep internal transformations within the members. According to Vygotsky (1978), social processes inform the psychological processes. Downloading and seeing represents the form of inter-psychological functioning, whilst the sensing and presencing spaces represent the form of intra-psychological functioning. Wertsch further adds "to understand the higher mental functioning of the intra-psychological plane, one must conduct a genetic analysis of its inter-psychological precursors" (1985, p 61). Sensing and presencing have not been used in this study as they are not the inter-psychological precursors. The inherent connection between the inter-psychological and intra-psychological plane is further discussed in Wertsch (1985).

Downloading here refers to creating an opportunity for learners to engage with existing ideas. From a constructivist point of view, this part of the process is important in learning. Previous ideas of the learners are building blocks for new ideas (Scott, Asoko, Driver and Emberton, 1994).

The **seeing** space of dialogue is considered as a data collection stage. Learners observe and listen attentively to the new information. They may also tend to ask more questions. This may be achieved through creating tools, activities and space that allows the learner to have an experience beyond his/her reality (Newman and Holzman, 1993). Crystallising, Co-creating and Co-evolving were physical outcomes which are evidence of the effectiveness of the

programme to influence the learners' attitudes. **Crystallising** refers to the learners' intention to change their attitudes. **Co-creating** occurred when learners explored by doing. The **Co-evolving** space is an indication of the learners' transformation.

5.2. Downloading

The pre-visit activity offered the learners an opportunity to download. They shared their experiences and confirmed what they knew about the consequences of inefficient use of energy. The downloading activity promoted collaborative learning. The learners had control of the learning process, they determined the pace of the activity and the teacher did not intervene. The downloading session offered valuable base line data for the research.

The following sections highlight two components that may inform us on the learners' attitude towards the environment; which include environmental knowledge and personal norms. As we recall from the literature, pro-environmental behaviour and good environmental knowledge does not equate to pro-environmental attitude, although it may offer some indication of the learners' attitude towards the environment. According to Hawthorne and Alabaster (1999), a desire to learn and to act is an indication of their attitude towards the environment. Furthermore, it has been established in the literature that there are situational factors that may be beyond an individual's control and may have no effect on their internal locus of control. Authority figures may limit the learners' decision making with regards to their lifestyle. This is further discussed in section 5.2.2.

5.2.1 Environmental knowledge

The environmental knowledge category includes the learner's ability to define concepts and identify factors related to various phenomena for example, naming an item responsible for carbon emissions, carbon emissions are responsible for the greenhouse effect. Most of the learners had convinced each other that they understood the various concepts, including global warming, climate change and the greenhouse effect. Similar to Kabelo and Tumelo, many of the learners in the classroom appeared to have a perceptual attitude towards the environment. The survey indicated that the learners have significant knowledge about environmental issues. They were aware of the causes and consequences of poor energy usage. Table 8 shows that more than half of the learners in the classroom could explain the greenhouse effect, global warming and climate change. Environmental information that the learners had, however, did not translate into behaviour change.

Table 8: Learners' prior knowledge and attitude towards sustainable energy use

Environmental Citizenship	N = 31
Environmental knowledge	
Can explain how being energy wise can lessen the impact of climate change	31
Can name 3 renewable source of energy	23
Can name 3 ways of saving energy	24
Knows what natural resource is used to make plastic	11
Can define sustainable use of natural resources	7
Can explain the Kyoto protocol	2
Can name an item responsible for carbon emissions	25
Can define what is climate change	19
Can define the term greenhouse effect	18
Can define what is global warming	25
Personal norms	
Uses a reusable lunch bag/container	8
Always switches lights off when leaving a room	7
Recycles at home	7
Has a compost bin at home	2
Grows their own vegetables at home	3
Has done an energy audit	13
Measures their own carbon footprint	1
Has planted indigenous trees at home or school	3
Belongs to an environmental club	3
Has started a recycling project at their school	1
Walks to school	5
Takes a bus to get to school	21
Uses a geyser blanket at home	2
Uses solar power at home or school	2

5.2.2 Personal norms

Personal norms refer to the learners' environmental behaviour influenced by situational factors Most of the learners did not declare a strong sense social responsibility towards the environment. Very little effort to conserve energy is demonstrated. Only seven out of thirty one learners recycled at home. Eight learners used a reusable lunch tin. Assuming all learners brought lunch to school, it may be inferred that the other twenty-three learners discarded their

lunch packaging every day. There is a possibility that some learners did not take any lunch to school. Thirteen learners had done an energy audit, indicating that they may have the intention of reducing their energy consumption. Many learners claimed to switch off the lights, which may be motivated by the learners' personal norms. Babcock (2009) defines norm as behaviour that is ingrained in an individual, and is generally unplanned. The personal norm may also be an attribute of the individuals' situational factor.

Learners may be citizens of the environment, but their behaviour may be strongly dictated by their parents, other authority figures and their socio-economic situation. The behaviour of the community may inform the learners' behaviour. This was evident from the responses of two of the questions with regards to the solar geyser and a geyser blanket. The learners were aware of renewable energy sources but only two learners indicated that they use solar power (a renewable energy sources) in their homes, which would be a reflection of environmental behaviour of the learners' parents. In South Africa, renewable energy technology is not widely used, only 0.01 % (BP, 2011). The response to this question may be very different from learners from Germany, as 17 % of their energy comes from renewable technologies. Most of the learners did not know what a geyser blanket was and did not use it at home. As we may recall, Kabelo equated a geyser blanket to an electric blanket. A geyser blanket is an insulator of heat, whilst an electric blanket conducts electricity. Surely if there are no geyser blankets or solar geysers in the community, the learners may not be able to understand technology which they have not seen.

Most learners travelled by bus to school. Compared to the five learners who travelled by car, they had a smaller carbon footprint. The learners were, however, not conscious of their pro-environmental behaviour as only one learner calculated her carbon footprint and only three learners have claimed to plant trees to offset their carbon footprint. This is in agreement with Dobson (2003) that the learners' environmental behaviour is not necessarily a product of their environmental attitude but their personal and social norms.

5.3. Seeing

The visit to Delta gave learners an opportunity to stop downloading and listen to facts. The group learning approach during the excursion was socio-cultural. The learners engaged in conceptual talk with the assistance of the education officers. They engaged in cognitive and

metacognitive learning, which includes "exploring" and "verifying solutions" (Dillenbourg, 1999). Various concepts and ideas about energy use and management were explored.
Teachers generally struggle to explain the processes involved with heat transfer (Lewis and Linn, 1994). Learners thus have inconsistent beliefs of these concepts. Lewis and Linn's study showed that some learners may believe that insulators generate heat instead of trapping heat. They may also believe that metals may store heat and cold and that wool conducts heat. The learners not only identified insulating materials but also examined and made inferences about the concept, "insulation". Lewin and Linn advise that when teaching a concept, the instructor should include "everyday activity into classroom activity to encourage integration of knowledge and develop alternative explanations for learner intuitive conceptions" (1994, p 674).

The peer collaboration was more successful in this movement. Mara and Samu helped each other develop an understanding of the concept of insulation. The learners were open to observing and gaining new information, and engaged in factual listening. Learners' conversations in informal learning environments may thus help them clarify their own understandings and allow them to explore different points of view. The collaborative discourse reasoning may have improved explanations at the individual level (Mason and Santi, 1998). The study was conducted in a learning environment that stimulated and supported verbal explanations and gave the learners an opportunity to critically evaluate environmental phenomena. Small group interactions where learners discussed theories, evidence and explanations were encouraged, which allowed students to construct their own knowledge (Van Zee et al, 2000). "Dialogues produced significant improvements in students' conceptual understanding", (Ravenscroft and Matheson, 2002, p 99). The authors further add that discussions allow learners to integrate scientific knowledge with pre-instructional concepts.

5.4. Crystallising

The learners constructed an action plan for their campaign. It included recycling and energy conservation techniques. They created a poster to pledge their intentions to efficiently use energy in their homes. The poster was a compilation of 16 learners' contributions. Each learner had written down his/her intentions on a piece of paper which was collated and presented on a poster. The list of items on the poster is presented in Table 9.

Switching off unused lights, using a geyser blanket to insulate a geyser, and closing the tap whilst brushing your teeth, showering instead of bathing and filling the kettle with one cup of water for one cup of tea were key points highlighted by the learners. The energy saving practice ideas were discussed during the excursion and were evidently stored in the learners' memory. According to Dias, Mattos and Balestieri (2004), information offered regarding conservation of energy is relatively elementary. Consumers are advised to turn off TVs and lamps that are not in use but are not made aware of more efficient technologies. The learners' response is typical, as most consumers are often poorly informed about energy efficient technologies and the impact they have on the environment (McKay, 2010).

Learners considered switching off their chargers to save energy significantly. However, the charger consumes the least amount of energy in our homes. According to McKay (2010), a cell phone charger that is switched on all day uses 0.01 Watt (W) of power which is equated to using one second of a car driving. The amount of energy wasted by switching on the cell phone charger for day is insignificant compared to using a computer that consumes approximately 55W of power when it is on but inactive. McKay argues that since 2005, the British Broadcasting Corporation advised people to turn off their mobile chargers to save energy. The media's efforts to educate people are often not validated or focus on low priority issues whilst the high priority issues are overlooked. He further adds that the campaign to switch off cell-phone chargers is a low priority issue, although it was strongly supported by the media of Britain. Dresselhaus and Thomas (2001) argue that the public are not aware of the challenges and progress of scientific and technological advances in developing alternative energy technologies. Difficulties of photovoltaics, photoelectron chemicals, fuel cells and other energy storage technology are not incorporated in energy conservation programmes, which is evident in this study as well. The arguments made by McKay, Dresselhaus and Thomas are valid but we cannot ignore the powerful effects of conserving energy of existing technologies. According to McKinney and Schoch (1998), merely switching from incandescent light bulbs to compact fluorescent bulbs would allow the US to shut down all their nuclear power stations. Majlath (2008, p 131) argues " if we regularly put out five unnecessarily used light bulbs, carbon dioxide emission annually decreases by 400 kilograms". By switching off unused lights, we may reduce our carbon footprint. The unknown is whether the learners are conscious of their carbon footprint whilst switching off unused appliances, as only one learner indicated that they will measure their carbon footprint.

Table 9: Learners intentions to practice sustainable energy use

Conserving electricity	Frequency
Switch the lights off when not in use	15
Switch the geyser off during peak period	10
Switch off the TV when not in use	5
Switch off the stove when not in use	1
Unplug cell-phone charges when not in use	9
Switch off the radio when not in use	1
Switch off the heater when not in use	3
For one cup of tea, pour one cup of water in kettle	9
Used to play my play station all night on weekend, but now I only play for 3 hours	1
Replace incandescent bulbs with compact fluorescent bulbs	3
Used to leave the refrigerator open	1
Used electric blankets, now I use a hot water bottle	2
Used to leave the air conditioner on for hours, now I take a walk for fresh air	2
Used the fan on hot days, now I open the windows	1
We bought electric blankets because there's no need to warm the house, but our beds	1
Walk instead of drive to the nearest shop , church	2
Recycling	
Use a recyclable green bag instead of plastic bags	3
Recycle plastic, paper and glass separately	4
I used throw my fruit and vegetables away, now I collect them in a compost bin	2
Energy management	
Measure carbon footprint	1
Pollution control	
Used to Litter, now I throw the trash away	2
Conserving water	
Used to bath, now we shower more often than we bath	4
Put a brick in the toilet to displace and save water	3
Used to wash with running water, now I use a stopper when washing dishes	1
I used to wash the dishes with plenty of water, now I use enough water	1
Close tap whilst brushing my teeth	1
Used to use a sprinkler, now I use a hosepipe	2
Used to water the garden with a hosepipe, now I use a bucket	5

The Energy Dialogues programme was aimed to teach learners about sustainable energy use and management using technology that they may have access to. Knowledge on energy storage technology is important for learners to know but will not encourage them to act. The learners' intention to conserve energy in their homes indicates that the information they received on the programme empowered them to act. The poster session expressed the learners' commitment to improve their lifestyles and indicates that to some degree the learners showed signs that they share some sense of personal responsibility. A learner commented, *"I have learnt to save energy and sustain for the future"*. The learners understood the cause of their actions and offered solutions. Their intentions are a reflection of their economic orientation. Conservation of electricity was the most common response to using energy in a sustainable way as the barriers to conserve energy in their homes are negligible. Recycling and energy management was not considered critical by most learners. According to Babcock (2009), individuals will change their behaviour if is convenient for them to do so.

5.5. Co-creating

The campaign preparations offered the learners an opportunity to co-create. Figure 4 demonstrates the learners working together creating their exhibit. The teacher became a member of the group; assigning roles and assisting them with their tasks. The co-creating movement offered an opportunity for cooperative learning. There were no extrinsic rewards and grades.

The learners' involvement was voluntary and the activities occurred after school. Cooperative learning was directed by social cohesion and cognitive elaboration perspectives. The learners identified the problems in their schools together, as well as the opportunities for change. The brick making process was task oriented. The learners learned by doing. Similar to the rational energy use programmes highlighted by Banciu and Alexandru (2011), the learners learnt key engineering principles.

Cognitive elaboration was identified as Tumelo and Mara assisted each other with their presentations. The interaction between the learners was brief. Tumelo filled the role of the expert learner, offering Samu advice on how to do her part of the presentation. They read their presentations to each other and learnt from each other.



Figure 4: Eco brick production

5.6. Co-evolving

The co-evolving space is defined by the learners' active involvement in their learning. The learners who volunteered to prepare the exhibit were invited to represent their school at an expo at DEC. The "Energy Dialogues" expo was an opportunity for selected Grade 11 learners to showcase their "Energy Dialogues" campaigns. Situated learning occurred during the co-evolving movement. The learners interacted with a panel of experts, and were given an opportunity to share their knowledge with them. Moreover, the expo at DEC offered the learners an opportunity to become legitimate participants in the community of practice. According to Wenger (1998), communities of practice develop around things that matter to its mission. The learners had decided to start an environmental club at their school. Recycling, reuse and reduce were the key foci to the campaign. Recycling was identified as a solution for pollution control. Reducing was illustrated in their poster, highlighting their intentions to reduce their energy consumption. The creation of the eco-brick, essentially a set of non-refundable glass bottles cemented together, was to demonstrate the learners' potential of reusing resources. Figure 5 presents the learners' exhibit.



Figure 5: Learners exhibit

5.7. Summary of the dialogue

The learners' prior knowledge was addressed through downloading space. In the seeing/observing space the learners carried out evidence based argumentation. Crystallising is evidence that learners shared a consensus about sustainable energy principles and approaches. Social cohesion was encouraged during the co-creating space. Co-evolving was the critical result, when the learners redefined their culture, physically engaged in activity and spoke the language of the educator. They became legitimate participants of the community of energy educators.

6 CONCLUDING THE DIALOGUE

This chapter deals with the research as a process. It addresses the research questions, defines the limitations and implications of the research and offers my personal reflection on the research process.

6.1. Research questions

The research questions 1 to 3 were resolved, although the research techniques and the complexity of researching the cognitive and affective components of learning have raised some uncertainties. The focus of research question 1 was on the affective component of learning, the learners' attitudes, whereas research questions 2 and 3 are more concerned with the context of learning, the space wherein learning occurred.

6.1.1 Research Question 1

To what extent do the Energy Dialogues at Delta Environmental Centre influence learners' attitude towards sustainable energy principles and approaches?

Research question 1, was an inquiry regarding the impact of the Energy Dialogues on the learners' attitudes towards sustainable principles and approaches. The findings indicate that the Energy Dialogues had a significant impact on the learners' attitude towards sustainable principles and approaches with regards to energy use and management. The learners had a desire to learn. The challenge to start a campaign motivated them to act. They developed innovative ideas based on sustainable principles and approaches that they were introduced to at DEC. Change in the learners' attitudes was demonstrated when they showed commitment to preparing for the campaign. Seven out of thirty schools presented their campaigns. The Energy Dialogues programme will not have the same impact on all schools and learners. Schools may have learners with various attitudes towards the environment; a school having learners with un-crystallised attitudes at the onset of the programme may not be affected at all, whilst others may have learners having strong emotional or perceptual attitudes.

6.1.2 Research Question 2

To what extent do the Energy Dialogues at Delta Environmental Centre create a space for learners to engage with the topic 'sustainable energy principles and approaches'?

There is sufficient evidence to back the claim that the Energy Dialogues offered the learners a cognitive and physical space to engage with sustainable energy principles and approaches.

The environmental and economic aspects of energy use and management were addressed. Below, I have highlighted the most significant events where conceptual knowledge about energy and conservation techniques was developed; and ideas on alternative energy technologies were explored.

In the energy room, the concept of insulation was examined with the use of practical examples such as carpets and ceilings. In the water room, the learners were exposed to water conservation techniques. For example, using a bucket instead of a hose pipe to wash a car and using bath water to water the garden. This activity addressed the learner's sense of personal responsibility, and made them aware of their own water consumption. The activity highlighted ways that they may have unconsciously wasted water in their homes. Learners were given an opportunity to link the cost of water usage to the cost of energy usage in their homes.

The activity, "everything comes from something", highlighted the importance of recycling. The activity informed learners of the energy usage during production of various materials including plastic, paper, aluminium cans and glass. The learners' economic orientation towards sustainable energy use was challenged. They were made aware of their buying power and the impact it has on the demand for natural resources. Furthermore, the importance of recycling to reduce the demand of natural resources was emphasised. The carbon footprint activity offered learners an opportunity for exploratory talk. They offered each other various scenarios regarding the carbon footprint of drivers. They highlighted the physical factors that may hinder a driver from commuting, such as the risk of rain storms when walking to work, or the lack of fellow colleagues living in the same area to commute together.

The information on the energy use and management was not too technical. One of the educators commented, "*the programme was so relevant that we need our grade 10 learners to also experience this.* The educator thus agreed that the programme was accessible to all the learners. The environment gave learners an opportunity to ask the necessary questions and offered them the ability to retrieve information through visual presentations, group work activity, reading and writing in worksheets. This observation is confirmed by another educator who observed the programme, "*The programme is very good because the learners study theory and practical of the topics in their work schedules, especially the contemporary ones such as energy, water and others"*. Another educator agreed *"This was well planned*

and learners were kept busy, very interesting and worthwhile for learners to experience energy issues. Booklets are user friendly". The only criticism received from the participant observers was from a female educator, who advised that the education officer should ask the learners questions individually to ensure better participation.

The physical space of the centre was, however, limited. Mara complained that the centre was not well equipped to demonstrate energy saving practices. She argued, "*We [are] talking about conserving natural resources, the place is not practising what they [are] preaching. They should run the whole place like they run their toilets*". The toilets at Delta are energy efficient, having dual flush systems. This insert indicates that the learner was very sensitive to the environment in which she was learning. The learner's observation may raise questions about the authenticity of the activities. A teacher observing the programme commented, "*I think that all the learners enjoyed the lessons. They were trying to answer all the questions by the facilitator. I also gained a lot of things as the educator, because at school we only do a lot of theory because of lack of resources".* Another educator confirmed, "*A programme like this is very beneficial as a lot of time is assigned to one topic plus there are all the practical examples like kettle, toilet, etc. which are on hand to be used. In a classroom, the relaxed atmosphere and facilities are not there".* We may thus conclude that the physical space adequately engaged the learners in dialogue about sustainable energy principles and approaches.

6.1.3 Research Question 3

To what extent do the Energy Dialogues at Delta Environmental Centre promote collaborative learning and offer the learners an opportunity to be actively involved in their own learning?

Collaborative learning was evident during the pre-visit activity and the excursion. During the pre-visit activity, the collaborative learning was discussion based whilst during the excursion the learners engaged in dialogue. The type of talk used in a discussion is defined by Wegerif, Mercer and Dawes (1999) as disputational talk, "characterised by disruptive disagreements and individual decision making" (p 496). The group failed to solve problems together or find suitable alternatives. Confident learners intimidated low achieving learners, which is in agreement with Blumenfeld et al. (1996). The claims of the low achieving learners were unwarranted as they had no evidence to back them up. Although cognitive conflict occurred,

the learners did not successfully help each other construct knowledge, as some issues were not completely resolved.

During the excursion, the learners participated in exploratory talk which ideally indicates that effective collaborative learning occurred as "learners engaged critically and constructively with each other's ideas; eventual agreement emerged as challenges were justified, alternative hypothesis were offered and knowledge was made public" (Wegerif, Mercer and Dawes, 1999, p 496). Six out of fifteen teachers agreed that the learners asked more questions than usual, two teachers disagreed, and the rest were not sure. The collaboration was more effective as the learners had the support of the facilitator to guide the discussions and ensured that the cognitive conflict was resolved. This was evident in the energy room when learners identified various insulation materials. In cases where the learners disagreed, the EO lowered the status of the learners' alternative conceptions and guiding them to discover the ideas that were more plausible. Furthermore, the exhibits offered learners opportunities to find alternative solutions. Dialogue based collaborative learning was more effective when learner conversations were guided.

6.2. Research tools

The multi-faceted survey initiated the first conversation amongst learners and encouraged them to explore phenomena about energy. It was fun and learners were given control and choice to answer questions. The survey promoted reciprocal teaching. A reciprocal teaching strategy engages with the learners' cognitive and interpersonal behaviours (Slavin, 1992). According to Slavin, reciprocal teaching is a small group strategy that turns the responsibility over to the learners to generate questions and offer each other elaborative explanations. They probed each other for the answers and consequently formed part of the research process. Learners questioned their consciousness of energy use and management before the excursion. The activity was effective because they learnt from each other, asking questions and reasoning with each other. Learners used qualitative reasoning to explain their understanding of phenomena. This is an achievement, as learners generally lack the necessary conceptual understanding to use qualitative reasoning (McDermott and Shaffer, 2000). The survey informed me of the learners' prior knowledge. Interviews and individual questionnaires before and after the excursion may have offered a voice to learners that were not confident to contribute verbally. As we may recall, Sue participated in the activities but did not share her ideas or concerns with the group.

6.3. Limitations of the research

The learners visit to DEC was a one-time occurrence, which indicates that I only captured a snapshot of the learning experience. “Learning is however a cumulative process” (Dierking et al., 2003, p 110). My study may inform a longitudinal study. Such a study would offer information of the causal relationships of the components which influence sustainable practices. According to Rennie, Feher, Dierking and Falk (2003), longitudinal studies may offer more information on how learning occurs.

According to Taylor et al. (2003), learner contributions may be influenced by a learner’s cultural preference or socio-economic status. The demographic characteristics of learners were not fully captured. The most common attributes amongst the learners was their age and school culture. The gender and age of learners were the only socio-demographic information that I collected. We cannot make any comment on the effect of the learners’ cultural preference. The study indicates that the learners’ parents may have a significant effect on their attitudes. Involving the parents in my study would have given me more conclusive information.

6.4. Implications

This study offers some critical information about the barriers to implement change and the conceptions that learners may hold with regards to energy use and management. More interestingly, the study highlights the importance of integrating various pedagogical approaches to engage learners. In this study the four types of group learning did not have the same effect on all the learners. This finding is further discussed in section 6.4.3.

6.4.1 Barriers to implement change

The learners may co-evolve within the classroom, internalising new concepts about energy use and management; however, the intentions may be limited to the classroom. The learner may internalise new information with regards to sustainable energy use; however, the new intentions of the learner may be less pronounced than the behaviour of the community. Knowledge built in the classroom is not easily transferred to the community. The learners complained that they failed to convince their parents of their intentions to change their habits in the home.

The role of the community is critical with regards to the learners’ response to environmental education, considering that the agenda of environmental education has changed from being

completely abstract to requiring active participation from the learners. The elders of the community may have a different perception of the environment. The community of the learners may hinder sustainable practices in the home. The learner may thus conform to the community's behaviour, creating cognitive dissonance. Babcock (2009) advises that the willingness of the community to change its habits is dependent on the community's internalisation of a social norm. It is thus imperative that these programmes are adapted to engage the community. Informal learning centres have the advantage of catering for all.

6.4.2 Learners' conceptions about energy use and management

Interestingly we find that learners still possess a number of alternative conceptions with regards to energy use and management after instruction.

The alternative conceptions learners may hold include:

- the learners were not aware on the insulating properties of a geyser blanket. The learners assumed that the geyser blanket is a conductor of electricity;
- certain learners were not sure what a solar panel looks like or any solar energy device;
- a learner confused the greenhouse effect with the breaking down of the ozone layer;
- learners cannot distinguish between an energy audit and carbon footprint;
- not all grade 11 learners know the consequences of the manufacturing process, for example the manufacturing of plastic as not known by most learners.

Teachers need to be aware of the alternative conceptions learners hold about various phenomena and processes, so that they may find good representations to ensure that they may construct their own knowledge successfully.

6.4.3 Learning approaches

My study indicates that not only do we have different group-work approaches to learning but there are different learners who are motivated by the different approaches. Furthermore, the learners may be influenced by the programme in different ways. Some may be affectively influenced whilst others more perceptually influenced by the programme. A good blend of various attitudes may assist in group learning, although learners with strong personality traits, if not managed, may hinder learning of others who have weaker personalities.

Perceptual learners may perform well with their role in the peer-collaborative group work. Knowledgeable learners were given an opportunity to refine the ideas they already possessed. The emotional learners were less assertive and did not have sufficient knowledge on the

topic. Emotional learners that make claims do not have the necessary information to back their claims. The Energy Dialogues approach followed the pedagogical approach proposed by Banciu and Alexandru (2011) to addressing education for sustainable development. The authors recommend that "teachers should encourage their students to carry out evidence-based argumentation. When a consensus is reached by embodying several viewpoints, science lessons become more interesting and students collaborate, encouraging social cohesion" (p 116). Hildreth and Kimble (2000), assert that people cannot work together or solve problems when they do not trust each other. Instructors and educators need to be aware of heterogeneous groups and manage their differences.

6.5. My reflection of the Energy Dialogues

This research has been the most thought-provoking experience in my life. On the journey of exploring the Energy Dialogues, it became apparent to me that my understanding of the world is based on a number of cultures. Throughout my life I have moved in and out of different communities of practice, each having its own culture. The cultures having the most significant impact include my family, my school, geoscience and science education. The Energy Dialogues programme offered me a special lens with which to view the world and address human issues.

As a scientist, I developed a vocabulary and framework that allowed me to communicate my ideas, claims and disagreements effectively (Edelson, 1997). The dialogue gave me an opportunity to construct and deconstruct my knowledge of the world. The system had clear rules, methods and techniques, which I used to prove my hypothesis. Within this discipline, we are very arrogant about our tools and techniques. At the onset of the literature review of this study, I recognised this arrogance. I often used a positivist lens to determine the validity of the approaches and ideas that were presented by the authors. The debate on climate change intrigued me, as the scientists offered evidence based arguments. The IPCC made strong arguments, but the information had very little impact on humanity. In a similar way, the learners had the necessary information about energy issues but that had very little impact on their attitudes towards energy use. With my positivist scientist hat, I failed to understand why the learners continued following unsustainable practices. Research on environmental citizenship offered me some understanding of their social processes. It became clear to me that rational thought was not enough to change the learners' minds. Cognitive processes would not offer all the answers. The learners wore different hats to mine, they were not

scientists. Their lives were governed by the social norms of their parents, a school culture and pressure of their peers. Collaborative group-work and dialogue addressed some of the social disparities, and the learners' engagement offered alignment of their campaign with the environmental movement of the international community. The cognitive processes were addressed using a rational approach to learning. Similar to Banciu and Alexandru, (2011), sustainable principles and approaches were motivated by the threat of climate change. Cognitive-conflict strategies offered learners an opportunity to re-evaluate their understanding of the environment and consequently responded positively towards environmental issues.

Based on my findings, it is my opinion that a combination of values based education and inquiry based learning will be effective. In my study, learners became actively involved in their campaign as a result of both collaboration and social cohesion.

7 REFERENCES:

Abu-Shumays, M. and Leinhardt, G. (2002). Two Docents in three museums: Central and peripheral participation. In Leinhart, G., Crowley, K. and Knutson, K. (Eds.), *Learning Conversations in Museums*, pp 45-79. London: Lawrence Erlbaum Associates Publishers.

Allen, S. (2002). Looking for learning in visitor talk. In Leinhart, G., Crowley, K. and Knutson, K. (Eds.), *Learning Conversations in Museums*, pp 259-301. London: Lawrence Erlbaum Associates Publishers.

Allen, S. (2004). Designs for learning: Studying science museum exhibits that do more than entertain, *Science Education*, 88 (1), pp S17-S33.

Anderson, J. R., Reder, L. M. and Simon, H. A. (1996). Situated learning and education, *Education Researcher*, 25 (4), pp 5-11.

Anderson, D., Lucas, K. B., Ginns, I. S. and Dierking, L. (2000). Development of knowledge about electricity and magnetism during a visit to a science museum and related post-visit activities, *Science Education,* 84, pp 658-679.

Andersson, B. and Wallin, A. (2000). Students' understanding of the greenhouse effect, the societal consequences of reducing CO_2 emission and the problem of ozone layer depletion, *Journal of Research in Science Teaching,* 37 (10), pp 1096-1111.

Ardoin, N. (2009). Behaviour change theories and free choice environmental learning. In Falk, J.H., Heimlich, J.E and Foutz, S. (Eds.), *Free Choice Learning and the Environment,* pp 57-73. New York: Altamira Press.

Babcock, H. M. (2009). Assuming personal responsibility for improving the environment: moving toward a new environmental norm, *Harvard Environmental Law Review,* 33, pp 117-175.

Bakobi, B., Chleshe, J. and Sgazzin, T. (1999). *Enabling EE: Guidelines for Environmental Education Policy and Strategy Processes in SADC states*, IUCN, the World Conservation Union.

Ballantyne, R. R and Packer, J. M. (1996). Teaching and learning environmental education: developing environmental conceptions, *Journal of Environmental Education*, 27 (2), pp. 25-32.

Banciu, D. and Alexandru, A. (2011). Greening dimension of learning in secondary schools, *Journal of Green Engineering*, 1 (2), pp 111-127.

Barrett, P. (2000). *Science and Theology since Copernicus*, Chapter 2, pp 12-24 and pp 55-59. Pretoria: UNISA Press.

Barry, J. (2003). 'Resistance is Fertile: Cultivating the Virtues of Sustainability Citizenship', *paper presented at 'Citizenship and the Environment' Workshop*, Newcastle University, 4-6 September 2003.

Bell, D. (2004). *Justice, Democracy and the Environment: A liberal conception of environmental citizenship, paper presented at PSA Annual Conference.* Political Studies Association.

Berkowitz, A. R., Ford, M. E. and Brewer, C. A. (2004). A framework for ecological literacy, civics literacy, and environmental citizenship in environmental education. In Johnson, E. and Mappin, M. (Eds.), *Environmental Education and Advocacy: changing perspectives of ecology and education*, part IV, pp 227 – 266. Cambridge University Press.

Blumenfeld, P. C., Marx, R. W., Soloway, E. and Krajcik, J. (1996). Learning with peers: From small group cooperation to collaborative communities, *Educational Researcher*, 25 (8), pp 37-40.

Bohm, D. (1996). *On Dialogue,* New York: Routledge.

Bowen, G. M. (2005). Essential similarities and differences between classroom and scientific communities, In Yerrick, R.J and Roth, W. M (Eds.), *Establishing scientific classroom discourse communities,* pp 109-138. Mahwah: Lawrence Erlbaum.

BP. (2011). BP statistical review of world energy, www.bp.com. Site visited in 29 July 2011

Braund, M., Lubben, F., Scholtz, Z., M., Sadeck, M., and Hodges, M., (2007). Comparing the effect of scientific and socio-scientific argumentation tasks: lessons from South Africa, *School Science Review,* 88 (324), pp 67-76.

Breakwell, G. M. (1995). Interviewing. In Breakwell G. M., Hammond S. and Fife-Schaw, C., *Research Methods in Psychology,* pp 230-242. London: SAGE Publication.

Brodie, K. (2006). Teaching mathematics for equity: Learner contributions and lesson structure, *African Journal of Research in SMT Education*, 10 (1), pp 13-24.

Brodie, K. and Pournara, C. (2005). Towards a framework for developing and researching group-work in mathematics classrooms. In Vithal, R, Adler, J. and Keital, C. (Eds.), *Mathematics Education Research in South Africa: Possibilities and Challenges*, pp 28-72. Pretoria: Human Sciences Research Council.

Broster, P., Carter, P. and James, H. (2009). Chemical systems, *Successful Physical science learner's book grade 11,* module 7, Oxford University Press.

Brown, J. S., Collins, A. and Duguid, P. (1989). Situated cognition and culture of learning, *Education Researcher*, 18 (1), pp 32-42.

Carlson, L. E. and Sullivan, J. F. (1998). Hands-on Engineering: Learning by doing in the integrated teaching and learning program, *International Journal of Engineering Education,* 15 (1), pp 20-31.

Caudwell, J. (2011). Energy Dialogues teachers preparation kit, Delta environmental centre.

Chen, T. B. and Chai, L. T. (2010). Attitude towards the environment and green products: Consumers perspective, *Management science and engineering*, 4 (2), pp 27-39.

Chisholm, L. and Leyendecker, R. (2008). Curriculum reform in post 1990's Sub-saharan Africa, *International Journal of Educational Development*, 28, pp 195-205.

Colardyn, D. and Bjornavold, J. (2004). Validation of formal, non-formal and informal Learning: policy and practices in EU Member States, *European Journal of Education, 39 (1),* pp 69-89.

Cortese, A. D. (2003). The critical role of higher education in creating a sustainable future, Planning for higher education, www.scup.org/asset/48483/cortese.pdf, assessed 16 March 2011.

Crowley, K. and Jacobs, M. (2002). Building islands of expertise in everyday family cctivity. In Leinhart, G., Crowley, K. and Knutson, K. (Eds.), *Learning Conversations in Museums*, pp 333-355. London: Lawrence Erlbaum Associates Publishers.

Dalton, D., Esterhuysen, P., Gordan, S., Jack, J., Joubert, L. and Pillay, V. (2006). *Shuters Geography Grade 11 learners book*, section E. Shuter and Shooter Publishers (Pty) Ltd.

Daniel, B., Stanistreet, M., and Boyes, E. (2004). How can we best reduce global warming? School students' ideas and misconceptions. *International Journal of Environmental Studies*, 61 (2), pp 211-222.

Demetriou, A., Shayer, M. and Efklides, A. (1992). *Neo-Piagetian theories of cognitive development: Implications and applications for education.* London and New York: Routledge

Denscombe, M. (2007). *The good research guide for small-scale social research projects*, Chapters 8 and 11. Maidenhead, England: Open University Press.

Dessel, A., Rogge, M. E. and Garlington, S. B. (2006). Using dialogue to promote social justice and change, *Social Work*, 51 (4), pp 303-315.

Dias, R. A., Mattos, C. R and Balestieri, J. A. P. (2004). Energy education: breaking up the rational energy use barriers, *Energy Policy*, 32, pp 1339-1347.

Dillenbourg, P., Baker, M., Blaye, A. and O'Malley, C. (1996). The evolution of research on collaborative learning. In Spada, E and Reiman, P. (Eds.), *Learning in humans and machine: Towards an interdisciplinary learning science*, pp 189-211. Oxford: Elsevier Ltd

Dillenbourg, P. (1999). What do you mean by learning? In Dillenbourg, P. (Ed.) *Collaborative-leaning: Cognitive and computational approaches*, pp 1-19. Oxford: Elsevier Ltd.

Dierking, L. D., Falk, J. H., Rennie, L., Anderson, D. and Ellenbogen, K. (2003). "Policy of the informal science education" Ad Hoc Committee, *Journal of Research in Science Teaching*, 40 (2), pp 108-111.

Djite, P. G. (2008). The nexus between education, learning and language, *UNESCO/UNU 2008: Conference on "Globalisation and Languages: Building on our rich heritage*". Japan: United Nations University.

Dobson, A. (2003). *Citizenship and the Environment*. Oxford: Oxford University Press.

Dresselhaus and Thomas, I.L. (2001). Alternative energy technologies, *Nature*, 414, pp 332-337.

Edelson, D. (1997). Realizing Authentic Science: Learning through the adaption of scientific practice, *International Handbook of Science Education*, Kluwer, Dordrecht, NL.

Ellenbogen, K. M. (2002). Museums in Family Life: An Ethnographic Case Study. In Leinhart, G., Crowley, K. and Knutson, K. (Eds.), *Learning Conversations in Museums,* pp 81-101. London: Lawrence Erlbaum Associates Publishers.

Ellinor, L and Gerard, G. (1998). *Dialogue: Rediscover the transforming power of conversation,* John Wiley and Sons Inc.

Erduran, S., Simon, S. and Osborne, J. (2004). Tapping into argumentation: Developments in the application of Toulmin's Argument Pattern for studying science discourse, *Science Education*, 88 (6), pp 915-933.

EU-OPEC. (2005). Energy Dialogue, Organisation of the Petroleum Exporting Companies, www.opec.org/opec_web/en/press_room/1010, site visited 5/5/2010.

Falk, J. and Dierking, L. D. (2002). Learning from the outside in. In Dierking, L. D. and Falk, J. H. (Eds.), *Lessons without limit: How free-choice learning is transforming education.* New York: Altamira press.

Falk, J. H., Heimlich, J. E. and Foutz, S. (2009). Introduction. In Falk, J. H., Heimlich, J. E. and Foutz, S. (Eds.), *Free Choice Learning and the Environment.* New York: Altamira press.

Falk, J. and Storksdieck, M. (2005). Using the contextual model of learning to understanding visitor learning from a science centre exhibition. In Dierking, L. D. and Falk, J. H. (Eds.) *Science, Learning in everyday.* Wiley Periodicals, Inc.

Feinberg, J. and Leinhardt, G. (2002). Looking through Glass: Reflections of Identity in Conversations at a History Museum. In Leinhart, G., Crowley, K. and Knutson. K. (Eds.), *Learning Conversations in Museums*, pp 167-211. London: Lawrence Erlbaum Associates Publishers.

Franklin, C. (1995). Expanding the vision of the social constructionist debates: Creating relevance for practitioners, *Families in Society: The Journal of Contemporary Human Science*, 54, pp 395-403.

Freire, P. (1992). *Education for critical consciousness*, New York: Continuum Publishing.

Gerber, R. (1996). Interpretive approaches to geographical and environmental education research. In Williams, M. (Ed.), *Understanding geographical and environmental education: The role of research*. Cassell Education.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research, *The Qualitative Report* 8 (4), pp 597-607.

Goldemberg, J. (2007). Energy choices towards a sustainable future, *Environment,* 49 (10), pp 7-17.

Graesser, A.C., Person, N. K. and Magliano, J. P. (1995). Collaborative dialogue patterns in one-to-one tutoring, *Applied Cognitive Psychology*, 9, pp 495-522.

Groenewald, T. (2004). Phenomenological research design, *International Journal of Qualitative Method,* 3 (1), pp 1-26.

Guba, E. and Lincoln, Y. (1989). *Fourth generation evaluation*, London: Sage Publications

Hansen, P. J. K. (2010). Knowledge about the greenhouse effect and the effects of the ozone layer among Norwegian pupils finishing compulsory education in 1989, 1993, and 2005-What Now? *International Journal of Science Education,* 33 (1), pp 397-419.

Hart, S. L. (1997). Beyond greening: strategies for a sustainable world, *Harvard Business Review*, January-February 1997, pp 66-76.

Hatch, J. A. (2002). *Doing qualitative research in education settings*, Chapters 2 and 4. New York: SUNY.

Hawthorne, M. and Alabaster, T. (1999). Citizen 2000: development of a model of environmental citizenship, *Global Environmental Change,* 9, pp 25-43.

Henning, E., van Rensburg, W. and Smit, B. (2004). *Finding your way in qualitative research*. Van Schaik Publishers.

Herrenkohl, L. R. and Guerra, M. R. (1998). Participant structures, scientific discourse and student engagement in the fourth grade, *Cognition and Instruction,* 16 (4), pp 431-473.

Hewson, P. W., Beeth, M. E. and Thorley, N. R. (1998). Teaching for conceptual change. In Fraser, B and Tobin, K.G. (Eds.), *International Handbook of Science Education,* pp 199-218. Dordrecht: Kluwer.

Hildreth, P. and Kimbel, C. (2000). Communities of practice in the distributed international environment, *Journal of Knowledge Management,* 4 (1), pp 27-38.

Hobson, A. (2003). Physics literacy, energy and the environment, *Physics Education,* 38 (2), pp 109-114.

Hofstein, A. and Rosenfeld, S. (1996). Bridging the gap between formal and informal Science learning, *Studies in Science Education*, 28, pp 87-112.

Houghton, J. T. (1991). The case of the greenhouse effect. In Thompson, P. and O Hara, J. P. (Eds), *Global warming,* chapter 1. John Wiley and sons.

Houghton, J. T. (2004). The impacts of climate change, *Global warming,* the complete briefing, chapter 7, pp 143-196, third edition. Cambridge University Press.

Isdo, C. D. and Isdo, S. B. (2011). *Carbon Dioxide and Earths' Future, pursuing a prudent path,* Centre for the study carbon dioxide and global change, www.co$_2$science.org, site visited, 3 July 2011.

Jackson, R. H. (2007). Social constructivism. *Introduction to International relations: theories and approaches,* Chapter 6, pp 162-176. Bath press Ltd.

Jansen, J. (1999). Setting the scene: Historiographies of Curriculum Policy in South Africa. In Jansen, J. & Christie, P. (Eds.), *Changing Curriculum, Studies on Outcomes-based education in South Africa,* Chapter 1, pp 3-18. Cape Town: Juta & Co.

Jimenez-Aleixandre, M. P., Rodriguez, A. B. and Duschl, R. (2000). *'Doing the lesson' or 'Doing science ':argument in high school genetics*. John Wiley and sons Inc.

Kaiser, F. G., Wolfin, S. and Fuhrer, K. (1999). Environmental attitude and ecological behaviour, *Journal of Environmental Psychology*, 19, pp 1-19.

Kenny, A. (2006). Energy supply in South Africa. In Winkler, H. (Ed.), *Energy policies for sustainable development in South Africa: Options for the future*, Chapter 4, pp 45-60. Energy Research Centre, University of Cape Town.

Koulaidis, V. and Christidou, V. (1999). 'Models of students' thinking concerning the greenhouse gas effect and teaching implications, *Science Education*, 83 (5), pp 559-576.

Kyle, W. C. (1999). Science education in developing countries: challenging first world hegemony in a global context*, Journal of Research in Science Teaching,* 36 (3), pp 255-260.

Lave, J. and Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press: Cambridge.

Lave, J. (1996). *Teaching, as learning, in practice, Mind, Culture and Activity*, 3 (3). pp 149-164.

Leinhardt, G. and Gregg, M. (2002). Burning buses, burning crosses: Student teachers see civil rights. In Leinhart, G., Crowley, K. and Knutson, K. (Eds.), *Learning Conversations in Museums,* pp 139-163. London: Lawrence Erlbaum Associates Publishers.

Lemke, J. L. (2001). Articulating Communities: Socio-cultural perspectives on science education, *Journal of Science Research in Science Teaching*, 38 (3), pp 296-316.

Lelliott, A. and Pendlebury, S. (2009). "A large object with a small museum": A Narrative analysis of Tlotlo's experience of an Astronomy Science Centre, *Curator,* 52 (3), pp 241-260.

Lewin, K. M. (2000). Mapping science education policy in developing countries, *World Bank Human Development Network, Secondary Education Series*. , The World Bank: Washington DC

Lewis, E. L. and Linn, M. C. (1994). Heat energy and temperature concepts of adolescents, adults and experts: Implications for curricular improvements, *Journal of Research in Science Teaching*, 31 (6), pp 657-67.

Luenddecke, S. B., Pinter, N. and McManus, S. A. (2001). Greenhouse effect in the classroom: A project – and laboratory – based Curriculum, *Journal of Geoscience Education,* 49 (3), pp 274-279.

MacGregor, S. and Szerszynski, B. (2003). 'Environmental citizenship and the administration of life', paper presented at '*Citizenship and the Environment' Workshop*. Newcastle University, 4-6 September 2003.

Majlath, M. (2008). Environmentally friendly Behaviour: Consistent or not? In Vadovics, E. and Gulyas, E., *Academic proceedings: Sustainable consumptions* 2008, chapter 9, pp 118-133. Sustainable Europe Research Institute.

Maluleke, N. N. (2005). T*he Impact of the National Environmental Education Policy initiatives in South Africa schools: study area: Soweto (Orlando East and West),* Masters' Thesis. University of Witwatersrand.

Maoto, S. and Wallace, J. (2006). What does it mean to teach mathematics for understanding? When to tell and when to listen, *African Journal of Research in SMT Education*, 10 (1), pp 59-70.

Mason, L and Santi, M. (1998). Discussing the greenhouse effect: children's collaborative discourse reasoning and conceptual change, *Environmental Education Research*, 4 (1), pp 67-83, Carfax Publishing Ltd.

Mbano, N. (2002). Verbal interactions in CASE lessons in Malawi, *African Journal of Research in SMT Education*, 6, pp 83-94.

McGinn, M. K. and Roth, W. (1999). Preparing students for competent scientific practice: Implications of Recent Research in Science and Technology Studies, *Education Researcher*, 28 (3), pp 14-24.

McKay, D. J. C. (2009). *Sustainable Energy-without the hot air*. CIT Cambridge Ltd.

McKinney, M. L. and Schoch, R. M. (1998). *Environmental science,* Chapter 1, pp 3-29. Jones and Bartlett Publishers International.

Myers, O. E., Saunders, C. D. and Bexell, S. M. (2009). Fostering empathy with wildlife: Factors affecting free-choice learning for conservation concern and behaviour. In Falk, J.H., Heimlich, J. E. and Foutz, S. (Eds.), *Free Choice Learning and the Environment,* pp 39-56. New York : Altamira Press.

Nesher, P. (1987). Toward and instructional theory: The role of students' misconceptions, *For the Learning of Mathematics,* 7 (3), pp 33-39.

Newman F. and Holzman, L. (1993). *Lev Vygotsky: Revolutionary Scientist,* pp 95-160. London: Routledge.

Nykiel-Herbert, B. (2004). Misconstructing knowledge: The case of learner-centred pedagogy in South Africa. *Prospects, 34* (3), pp 249-264.

Oelsner, H. (2007). South African Neet Workshop, Retrieved 3 November 2010, from www.iea.org/work/2007/neet/oelsner.pdf.

Ocker, R. J. and Yaverbaum, G. J. (2001). Collaborative Learning Environments: Exploring student attitudes and satisfaction in face-to-face and asynchronous computer conferencing settings, *Journal of Interactive Learning Research*, 12 (4), pp 427-448.

Omer, A. M. (2008). Energy, Environment and sustainable development, *Renewable and Sustainable Energy Reviews*, 12, pp 2265-2300.

Opie, C. (2004). Research procedures, *Doing educational research*, Chapter 5. London: Sage Publishers.

Packer, J. (2006). Learning for fun: The unique contribution of educational leisure experiences, *Curator,* 49 (3), pp 329-344.

Piaget, J. (1964, 2003). Development and learning, *Journal of Research in Science Teaching*, 40, pp S8-S18.

Piccoli, G., Achmad, R. and Ives, B. (2001). Web based virtual learning environment: A research framework and a preliminary assessment of effectiveness in basic IT skills training, *MIS quarterly*, 25 (4), pp 401-426.

Pillay, R. P. (2008). *Exploring the engagement of an environmental centre with the discourse of sustainable development: A Southern African case study*. Doctoral Thesis. University of Witwatersrand.

Polkinhorne, D. E. (1995). Narrative configuration in qualitative analysis. In Hatch, J.A. and Wisniewski (Eds.), *Life History and Narrative,* pp 5-24. London: The Falmer press.

Pooley, J. A. and O'Connor, M. (2000). Environmental education and attitudes: emotions and beliefs are what is needed, *Environment and Behaviour*, 32 (5), pp 711-723.

Popper, K. R. (1963). *Conjectures and refutations: The growth of scientific knowledge.* London: Routledge.

Prasad, G. (2006). Social issues. In Winkler, H (Ed.), *Energy policies for sustainable development in South Africa: Options for the future*, Chapter 4, pp 61-70. Energy Research Centre: University of Cape Town.

Prince, D. (1990). Factors influencing museum visits: An empirical evaluation of audience selection, *Museum management and curatorship*, 9, pp 149-168.

Ravenscroft, A. and Matheson, M. P. (2002). Developing and evaluating dialogue for collaborative e- learning, *Journal of Computer Assisted Learning,* 18, pp 93-101.

Rennie, L. J., Fehere, E., Dierking, L. D. and Falk, J. H. (2003). Toward an agenda for advancing research on science learning in out-of-school settings, *Journal of Research in Science Teaching*, 40 (2), pp 112-120.

Robbins, S. P. and Judge, T. A. (2009). *Organizational Behaviour,* Edition 13. Prentice hall: Pearson Education International.

Roberts, M. (1996). Case Study research. In Williams, M. (Ed.), *Understanding geographical and Environmental Education: The role of research*. Cassell Education

Rokicka, E. and Stomczynska, J. (2002). Attitudes towards natural environment: A study of local community dwellers, *International Journal of Sociology*, 32 (3), pp 78-90.

Rogan, J. and Grayson, D. (2003). Towards a theory of Curriculum implementation with particular reference to science education in developing countries, *International Journal of Science Education,* 25 (10), pp 1171-1204.

Rogan, J. (2007). An uncertain harvest: a case study of implementation of innovation. *Journal of Curriculum Studies,* 39 (1), pp 97-121.

Rollnick, M., Bennett, J., Rhemtula, M., Dharsey, N. and Ndlovu, T. (2008). The place of subject matter knowledge: A case study of South African teachers teaching the amount of substance and chemical equilibrium, *International Journal of Science Education*, 30 (10), pp 1365-1387.

Rollnick, M. (2000). Current issues and perspectives on second language learning of science. *Studies in Science Education, 35*, pp 93-122.

Rosenthal, E. and Blankman-Hetrick, J. (2002). Conversations across time: Family learning in a living history museum. In Leinhart, G., Crowley, K. and Knutson, K. (Eds.), *Learning Conversations in Museums,* pp 305-328. London: Lawrence Erlbaum Associates Publishers.

Scaife, J. (2004). Reliability, validity and credibility. In Opie, *Doing educational research,* pp 58-72. London: Sage.

Schamadinger, B. and Marland, G. (1998). The Kyoto Protocol: provisions and unresolved issues relevant to land-use change and forestry, *Environmental Science and Policy*, pp 313-327. Elsevier Ltd.

Scharmer, O. (2007). *Theory U: Leading from the future as it emerges.* The society for organizational learning.

Schein, E. H. (1993). On dialogue, culture, and organizational learning, *Organizational dynamics*, 22, Elsevier Science Ltd.

Scholtz, Z., Braund, M., Hodges, M., Koopman, R. and Lubben, F. (2008). South African teacher's ability to argue: The emergence of inclusive argumentation, *International Journal of Education Development*, 28, pp 21-34.

Scott, P., Asoko, H., Driver, R. and Emberton, J. (1994). Working from children's ideas: planning and teaching a chemistry topic from a constructivist perspective. In Fensham, P., Gunstone, R. and White, R., *The Content of Science: a constructivist approach to its teaching and learning*, pp 201-220. London: Falmer Press.

Seale, C. (1999). Quality in qualitative research, *Qualitative Inquiry*, 5 (4), pp 465-478.

Shibley Jr., I. A. and Zimmaro, D. M. (2002). The influence of collaborative learning on student attitudes and performance in an introductory chemistry laboratory, *Journal of Chemical Education*, 79 (6), pp 745-748.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching, *Education Researcher*, 15 (2), pp 4-14.

Sikes, P. (2004). Methodology, procedures and ethical concerns. In C Opie, *Doing educational research,* pp 15-33. London: Sage.

Simon, S. and Maloney, J. (2007). Activities for promoting small-group discussion and argumentation, *School science review*, 88, (324), pp 49-58.

Slavin, R. E. (1992). When and why does cooperative learning increase achievement? Theoretical and empirical perspectives. In Hertz-Lazarowitz, R and Miller, N. (Eds.), *Interaction in cooperative groups: The theoretical anatomy of group learning,* pp 145-173. New York: Cambridge University press.

Smith, J. P., DiSessa, A. A. and Roschelle, J. (1993). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The Journal of the Learning Sciences,* 3(2), pp 115-163.

Sparks, D. (2006). Energy and the environment. In Winkler, H. (Ed.), *Energy policies for sustainable development in South Africa: Options for the future*, Chapter 7, pp 88-100. University of Cape Town.

Stapp, W. (1969). The concept of environmental education, *the Journal of Environmental Education*, 1 (1), pp 30-31.

Stern, P. C. (1986). Blind spot in policy analysis: what economics doesn't say about energy use, *Journal of Policy Analysis and Management*, 5 (2), pp 200-227.

Stoffels, N. (2005). "There is a worksheet to be followed": A case study of science teacher's use of learning support texts for practical work, *African Journal of Research in SMT Education*, 9 (2), pp 147-157.

Suzuki, M. and Oka, T. (1998). Estimation of life cycle energy consumption and CO_2 emission of office buildings in Japan, *Energy and Buildings*, 28, pp 33-41.

Taylor, N., Muller, J. and Vinjevold, P. (2003). *Getting schools working: Research and systemic school reform in South Africa*. Pearson Publishers.

UNEP (2002). Integrating environment and development: 1972-2002, *Global Environment Outlook 3*, Chapter 1. Earthscan Publications Ltd.

UNESCO-UNEP. (1976). The Belgade Charter: A global framework for environmental education, *UNESCO-UNEP Newsletter*, 1 (1), pp 1-2.

van Huis, C. and van den Berg, E. (1993). Teaching energy: a systems approach, *Physics Education*, 28 (3), pp 146-153.

van Zee, E. H., Iwasyk, M., Kurose, A., Simpson, D. and Wild, J. (2001). Student and teacher questioning during conversations about science, *Journal of Research in Science Teaching*, 38 (2), pp 159-190.

von Glasersfeld, E. (1991). A constructivist's view of learning and teaching. In Duit, R. Goldberg, F. and Niedderer, H. (Eds.), *Researcher in physics learning: Theoretical issues and empirical studies* pp 29-39. Kiel:IPN

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes,* pp 79-120. Cambridge, MA: Harvard University Press.

Wegerif, R., Mercer, N. and Dawes, L. (1999). From social interaction to individual reasoning: an empirical investigation of a possible socio-cultural model of cognitive development, *Learning and instruction*, 9, pp 493-516.

Wenger, E. (1998). Communities of practice: learning as a social system, *Systems Thinker*, 9 (5), pp 1-10.

Wenger, E. (2000). Communities of practice and social learning systems, *Organisation articles*, 7 (2), pp 225-246.

Wertsch, J. V. (1985). The social origins of higher mental functions, *Vygotsky and the social formation of mind*. Chapter 3. Cambridge MA: Harvard University Press.

Wigley, J. (2003). *Methods, activities and theories for environmental education*, Sharenet Resource.

Winkler, H. (2009). Modelling Energy policies, *Cleaner Energy, Cooler climate: developing sustainable energy solutions for South Africa,* Chapter 5, pp 99-142. HSRC Press.