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Where leaders learn

A review of how teachers are using the Renewable Energy materials in their lessons

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Abstract

A review of how teachers are using the Renewable Energy materials in their lessons

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Abstract

Climate change and renewable energy have recently become part of the school curriculum in South Africa. Many teachers at the secondary school level thus have to teach topics with which they are not (necessarily) familiar. The Centre for Renewable and Sustainable Energy Studies at Stellenbosch University has established a schools' programme to provide materials to aid the educators in the teaching of renewable energy topics. A research-based set of Learning Teaching Support Material (LTSM) was developed for high school educators. The learning material includes a DVD, PowerPoint presentations, posters, a teacher's manual, and assignments that can be used in different subjects.

This study reports and reviews how teachers are currently using the material. Teacher accounts of materials use and evidence of learning in students work were solicited using an appreciative inquiry review process. The data reflected the value being created through patterns of materials use. A Vygotskian based task sequencing framework of Anne Edwards was used to examine the patterns of use which support learning.

The use of the task sequencing as an analytical lens allowed the review to probe how knowledge representation was the primary use by teachers. Here they introduced learners to key concepts and to broaden their knowledge on renewable energy. The activities served to scaffold a clear learning progression but the activities were not strongly enough orientated towards ESD as learner-led processes of enquiry and action. The outcomes of the study will be used to update and better align the materials with a need for teachers to strengthen important ESD outcomes in the current curriculum.

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List of Acronyms

ANA	Annual National Assessments – Department of Basic Education
CRSES	Centre for Renewable and Sustainable Energy Studies
CAPS	Curriculum and Assessment Portfolio Statement
DoE	Department of Energy
DEA	Department of Environmental Affairs
DME	Department of Minerals and Energy
DST	Department of Science and Technology
EE	Environmental Education
EEASA	Environmental Education Association of Southern Africa
ELRC	Environment Learning and Research Centre
ESD	Education for Sustainable Development
EU	European Union
GAP	Global Action Programme
GEM	Global Education Monitoring
IOB	Inspectie Ontwikkelingssamenwerking en Beleidsevaluatie
IPP	Independent Power Producer
IRP	Integrated Resource Plan
LTSM	Learning and Teaching Support Materials
NAAEE	North America Association for Environmental Education
NDP	National Development Plan
NRF	National Research Foundation
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
REN21	Renewable Energy 21st Century
RU	Rhodes University
SDG	Sustainable Development Goals
SU	Stellenbosch University
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCC	United Nations Framework Convention on Climate Change
WWF	Word Wide Fund
ZPD	Zone of Proximal Development

Chapter 1 Introduction and Context

1.1 Introduction

The Renewable Energy Schools' Programme was developed to address a number of issues relevant to the youth of today: socio-ecological challenges, the results of climate change and the accompanying environmental impact, and the need for a sustained energy supply in South Africa. The material under review in this research thesis is part of the Renewable Energy Schools' Programme and was designed and implemented by the Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University (SU).

The rationale for this study is to review the patterns of use by teachers of the renewable energy learning material.

This chapter introduces both the broad and specific context of the research and presents the historical and contextual background of the schools' programme. The research rationale, research question and research goals are introduced and a brief overview of the study is mapped out.

1.2 Historical and contextual background to the programme

The schools' programme on renewable energy was developed after an awareness gained of misinformation by teachers to learners. The researcher identified the urgent need for Education for Sustainable Development (ESD) on renewable energy to be provided to teachers in order to assist and support education in this relatively new learning area.

The value of the programme goes deeper than simply increasing awareness of the teachers; the goals and objectives of the Renewable Energy Schools' Programme are in line with a number of national strategies and objectives in terms of education development, resource sustainability, environmental impact awareness and job creation. These are discussed in more detail below.

1.2.1 National government's strategy

One of the key objectives of the South African government's enabling education framework is to raise public awareness on renewable energy and educate the public of its benefits and opportunities. As a result, capacity will be developed in order to make use of these benefits and opportunities, resulting in increased employment opportunities.

1.2.2 Job opportunities

The higher education environment serves as an integral mechanism to achieve this objective. Through education, the Renewable Energy Schools' Programme not only responds to education about climate change but also supports the National Development Plan's (NDP) priorities to stimulate investment, as well as to promote and develop technical job opportunities in the renewable energy industry (National Development Plan (NDP), 2012).

1.2.3 Renewable Energy Independent Power Producer Procurement Programme (REIPPPP)

The South African Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) specifies that power generation site developers must show how the communities within a 50 km radius of project sites will benefit from the project's revenue. This implies that the Independent Power Producer (IPP) programme has the potential to leverage the economic, social and local development of such a community and the Renewable Energy Schools' Programme can contribute to this development.

1.2.4 Curriculum

Probably the most important reason why the schools' programme was developed is that climate change and renewable energy have recently become part of the school curriculum in South Africa; this implies that most teachers at secondary school level have to teach topics with which they are not (necessarily) familiar.

Following the introduction of the National Natural Sciences Curriculum (2000), CRSES identified the need to assist teachers with lesson materials on renewable energy. The Curriculum Assessment Policy Statement (CAPS) (2012) included a component on sustainable and renewable energy in various subjects; this brought about a new challenge as most teachers were not sufficiently educated in this field as they had not received formal training on the topic they were expected to teach.

There were also very few resource materials available, due to the newness of this subject, as part of the curriculum. It is to this end that the Renewable Energy Schools' Programme was developed to empower teachers to effectively facilitate learning about climate change and renewable energy and how renewable energy can counteract climate change. This was achieved by broadening the knowledge of teachers on renewable energy and providing them with appropriate subject materials to ensure effective implementation in classrooms.

With this in mind, a set of material was developed for high school teachers. The dissemination of these materials takes place through teacher training workshops which are done through the existing school networks. The materials were introduced in six provinces where a total of more than a thousand teachers have been trained on the topic and the use of the materials in their lessons since 2008.

The materials include:

- A DVD: 'Planet Earth - a Living Heritage', showing the negative effects of pollution and climate change as well as possible solutions;
- Eight modules: Developed as PowerPoint presentations with pictures and written text. Presentations are available in Afrikaans and English and are loaded on a CD;
- Eight posters, one for each module; and
- A Teacher's Manual with guidelines and assignments.

The assignments were specifically developed to enhance the renewable energy sections in the curriculum of the following subjects:

- Geography for grades 10-12
- Natural Science for grades 7-9
- Mathematics for grades 7-9
- Physical Science for grades 10-12

The learning focus of the material is to emphasise the importance of changing our energy use and to give an overview of renewable energy sources; the focus is not on a specific subject. The material provides a strong visual impact through the use of the DVD, PowerPoint presentations and posters. This was done to cover as many aspects of the different topics as possible.

Previous appraisals, questionnaires, workshop evaluations and surveys of the past nine years focused mostly on *whether* teachers used the learning material, but little information was gathered and documented on *how* the material was used.

1.3 Research rationale, question and goals

The rationale of this study is to determine how teachers use the materials and whether value is added to their teaching and learning practises to further ESD. The results will be used to not only update the materials but also to inform and improve the teacher professional development workshops.

Therefore, the question asked in this research is how do teachers use the renewable energy learning materials?

The goals of the study are:

- To determine the patterns of use. (The Vygotskian-based learning task sequence framework of Anne Edwards will be used for analysis here).
- To determine what value was created for the teacher in their teaching and learning practices.

1.4 The researcher as programme developer

The researcher is closely involved with the schools' programme and has been since its inception in 2008. It has been initiated, planned, developed, disseminated and implemented by her. The schools' programme consists of a number of different aspects: the learning materials, the establishment of networks within existing school networks, the presentation of teacher professional development workshops, and sourcing funding for the programme. All of these aspects are handled by the researcher.

This study only focuses on the aspect of the learning materials and specifically, on how teachers use them.

1.5 Overview of the study

Apart from this introduction, this study has another six chapters investigating the above-mentioned research question.

Chapter 2 discusses current literature around the conceptual and theoretical framework used in the study. To explain and expand the concept of sustainable development, the importance of renewable energy is discussed from an environmental, social and economic point of view, not only in South Africa but also in other parts of the world. Also discussed is ESD in terms of the development of schools' learning material. This is followed by a discussion on the Anne Edwards learning task sequence and its use in the research.

Chapter 3 describes the methodology and research design chosen for this study. In this chapter, the research process is discussed as well as the different research activities that were used to gather the data. The study was undertaken as an interpretive qualitative review. The Anne Edwards learning task sequence theory was used to determine the patterns of how the learning material

was used. An abductive analysis of the value that was created for teachers and for further development of the materials was also done.

Background information on the schools' programme is presented in Chapter 4. This includes a summary of the ongoing research done since the start of the schools' programme which includes a pilot study, telephonic survey, workshop evaluations and email surveys carried out since 2013.

Chapter 5 presents the data generated in the research. Feedback received from five teachers is presented as individual cases, by identifying the patterns of how the learning materials were used, as well as the value generated for the teachers.

Chapter 6 discusses the results presented in Chapter 5 as it relates to the theoretical and conceptual framework presented in Chapter 2. The research goals are also discussed through the learning task sequence and value creation.

In Chapter 7, an overview of the research is given, with the developed conclusion and recommendations are made for future studies.

Chapter 2 Literature Review

The rationale for this study, as stated in Chapter 1, is to review reported patterns of use of the renewable energy learning materials.

2.1 Introduction

To place this study in context, a literature review is given in this chapter on the key concepts of some of the leading researchers in the field of renewable energy and learning material for ESD. As there is a close connection between climate change, sustainability and the development of renewable energy solutions, the essence of sustainable development and what climate change entails will also be explored.

The chapter also outlines the learning task sequencing of Edwards (2014). This was used as a lens to review the patterns of use of the learning material by the teachers and as an analytical vantage point for contemplating ESD learning processes towards future sustainability. Insights on task sequences that support learning, the heart of this study, will be used to inform the improvement of the resource and to enhance teacher support in our continuing work.

2.2 Sustainability concepts explained

Sustainability is "the ability to keep the welfare of both humans and the environment in focus at the same time and to insist on both" (Meadows, 1995). This definition provides a useful vantage point on how the renewable energy learning material under review has been developed to contemplate states of future sustainability for humans to continue to thrive in a healthy environment, in a modern era characterised by risk (Beck, 1992).

Modernity is characterised by "city-based" civilizations which have functioned as linear systems, where resources flow through the system with little thought as to where these resources come from, how they were produced and where the waste they generate might end up. Such linear systems are not sustainable as they are very different to natural ecosystems, which are cyclical, where resources and waste are continually being recycled. This current tension between civic and natural systems is described in the DVD: 'Planet Earth a Living Heritage', (2008) an orientating resource for the renewable energy learning material.

The question of sustainable development is scoped in the Brundtland Report (1987) a commission that defined "sustainable development as development that meets our present needs, without compromising the ability of future generations to meet their own needs"

(Brundtland Report, 1987, p. 43). In other words, the decisions we make, and the actions we take today – to provide for food, shelter, energy, clothing, and other needs which at the moment are achieved with linear flows – should not jeopardise the natural life-supporting systems which operate in cycles. In this study sustainability is generally referred to as an ecological, economic and social balance in the quest for social-ecological development and overall quality of life (McKeown, 2002).

Transitioning to more sustainable development is therefore the pathway to continued sustainability. As Donella Meadows pointed out, it is to "keep the welfare of both humans and the environment in focus at the same time" (Meadows, 1995). For this, education is fundamental in order to change mind-sets and increase awareness to accomplish sustainable development and thereby ensure future sustainability.

In South Africa, our Constitution states that to create a healthy environment not only for the present generation but also for generations to come, is the duty of any organisation involved in sustainability (Bill of Rights, 1996). The Global Education Monitoring report (GEM), defined sustainable development as an "organizing principle for global development that supports the wellbeing of both people and the planet" (GEM, 2016, p. 3).

According to the ESD toolkit version 2 by McKeown (2002), sustainability is used as a paradigm of thinking or a decision making framework where the decisions are ecologically, economically and socially sound. This framework will be used to discuss why it is important to consider renewable energy as a source of energy. Further, it is crucial that we share this knowledge with future generations through education, and hence the development of the material for the schools' programme.

2.2.1 Contradictions in current patterns of energy use

To date, the world economy has relied on fossil fuels as its main source of energy. This has created a negative impact on the environment in terms of mining, resource depletion and climate change. The use of non-renewable resources will therefore have to be changed or we will not be able to meet a future energy demand in perpetuity (Boyle, 2012) as these resources will be depleted.

2.2.2 Climate change as an outcome of unsustainable energy use

The concept of climate change first appeared in 1956 in a seminal study called "The Carbon Dioxide Theory of Climatic Change" by Gilbert Plass. In 1989 Margaret Thatcher referred to the concept in her address to the United Nations where she said that climate change affects us all and should be acted on, internationally as well as nationally (Cook, 2013).

Climate change refers to the fact that, as a result of the burning of fossil fuels for human activities, certain gasses have been added to the atmosphere causing a greenhouse effect and resulting in changes in the climate (Boyle, 2012).

At the moment there are two distinct viewpoints on the cause of climate change: whether climate change is a natural occurrence in the climatic cycle of the earth, or whether it is caused by humans. The latter is backed by the fact that scientists have observed a steady increase in the average temperature of our planet since the industrial revolution (Boyle, 2012), when more and more fossil fuels were burned for energy generation.

In the 2015 report on Planetary Boundaries 2.0 by the Stockholm Resilience Centre, it is stated that four of the earth-systems processes, namely climate change, loss of biosphere integrity, altered biogeochemical cycles and land-system change, have exceeded their boundaries and that altering either of the so called core-boundaries of climate change and biosphere integrity, earth-systems can be driven to a new steady state (Steffen, Richardson, Rockström, Cornell, Fetzer, & Biggs, 2015). This implicates that we have to act on the cause of climate change immediately in order to prevent further escalation in climate change.

2.2.3 Socio-economic risks

The one thing climate change is causing is uncertainty, and hand-in-hand with uncertainty goes an increase in risk. The Planetary Boundaries 2.0 report also notes that the boundaries of the systems of the earth are linked with one another, and they are uncertain of what will happen to one system if another system exceeds its boundary (Steffen *et al.*, 2015). Today there is still uncertainty amongst scientists as to how long it will take for irreversible environmental change to take place.

Adding to the uncertainty of the long term **environmental** effects of climate change are the **social** risks that it presents and Beck (1992) rightly mentions that "because of its systemic often invisible nature, risk is open to social definition and construction". To this Giddens (1999) added that risk is closely linked to probability and uncertainty. At this point in time, climate change is causing socio-ecological risks that we can't yet anticipate and therefore don't know how to

address. What we do know is that climate change will have far-reaching effects on us, our food supply, and the whole natural world.

Together with the socio-ecological issues and risks that climate change is posing, we are also **economically** challenged with the need to generate a sustainable amount of energy, not only in South Africa but also in other parts of the world.

2.2.4 The emergence of renewable energy as a solution for change

Renewable energy refers to energy generated by resources that replenish themselves continually, for example, the sun, wind, water, biomass and geothermal sources.

Renewable energy can address all of the socio-economic risks mentioned above. Not only can renewable energy counteract climate change but it can also address the challenge of producing a sustained amount of energy (Boyle, 2012).

In response to an alternative to burning fossil fuels for the generation of energy, the Renewable Energy Status Report (REN21) stated that globally there is an awareness that renewable energy does not only address the **environmental** challenge of climate change, but can create **economic** opportunities for a number of people who are still living without access to modern energy (REN21, 2015). Modern energy refers to the accessibility to electricity and the potential to make use of electrical appliances and clean cooking facilities which lessen indoor air pollution.

This implies that renewable energy can be the answer to the Secretary-General of the United Nations Development Programme's (UNDP) call for universal access to modern energy by 2030 (UN, 2011)and the Sustainable Development Goal (SDG) (August 2015) Goal 7, in terms of energy, namely "to ensure access to affordable, reliable, sustainable and modern energy for all" (United Nations Sustainable Development Goals, 2015).

In line with this call is a study conducted by the Dutch Ministry of Foreign Affairs (IOB), on *Promoting Renewable Energy Programme in Sub Sahara Africa, Malaysia and Nepal,* which showed that access to energy (in this case renewable energy) does not directly lead to but is a precondition for most Millennium Development Goals (now the Sustainable Development Goals). The IOB study discussed the findings of the positive effect that access to electricity has in these countries in terms of health, security, communication and commercial activities (Inspectie Ontwikkelingssamenwerking en Beleidsevaluatie (IOB), 2013).

One such example discussed in the report is that, in terms of education, better school performance was not significantly associated to additional study hours at home where often there is a lack of access to electricity, but rather to school being connected to electricity. This enables the school to attract better teachers and to offer better education. The report further highlights that an essential element for sustainable development was access to energy and thus renewable energy can be the solution to two global challenges namely: sustainable development and stopping climate change (*ibid.*).

In addition to the IOB research is the **socio-economic** view of the 2016 PricewaterhouseCoopers report, *'Electricity beyond the grid: accelerating access to sustainable power for all'*. It states that a decrease in cost, the pace at which renewable energy technologies develop and the ability to operate independently from the traditional power grids, means that renewable energy can grow exponentially, and can therefore supply Africans in their main needs, such as lighting, accessing information on cell phones and television, and electricity for energy efficient appliances. This report also stated that policymakers will have to rethink access to electricity that relies on off grid technology (PricewaterhouseCoopers, 2016).

Because of the small scale off-grid possibilities, renewable energy can lead to energy affordability for more people and can therefore not only raise their quality of life but also their capabilities and employment opportunities (Sen, 2001) and could therefore bring relief to poverty. According to Swilling (2016) 50% of Africa's energy needs can be met by 2050 by using renewable energy.

From the above it is proposed that renewable energy can address improvement in people's livelihoods especially for those who have not access to modern energy, and therefore it can provide a solution to the SDG 7 of providing "access to affordable, reliable, sustainable and modern energy for all" (United Nations Sustainable Development Goals, 2015).

2.2.5 Renewable energy in developed countries

But what is the state of affairs of renewable energy in developed countries? This question can be answered as follows:

In 2005 the European Union (EU) set out renewable energy targets to reduce the effects of climate change and establish a common energy policy. The target is that, by 2020, renewable energy should account for 20% of the EU's final energy consumption, up from the 8.5% in 2005. The latest figures available are that the share of renewables in energy consumption in the EU rose to 16% in 2014 (Sturc, 2016).

Furthermore, the latest REN21 (2016) report states that renewable energy has established itself **economically** as a mainstream energy source in other parts of the world. Tendencies that led to this development are the improvement of cost-competiveness of renewable energy technologies as well as better policy initiatives, access to financing, environmental concerns and a growing demand for energy in developing and emerging economies (REN21, 2016). The situation in South Africa specifically is discussed in the paragraph below.

2.2.6 Renewable energy in South Africa

South Africa's current energy supply is mainly derived from burning fossil fuels, which is a non-renewable resource and has led to climate change. Due to the fact that South Africa is an energy intensive country and is relying on coal for primary energy use, it is one of the largest emitters of greenhouse gasses in Africa and one of the most carbon emission-intensive countries in the world (Department of Minerals and Energy (DME), 2003). The Global Carbon Atlas (2014) results showed that South Africa is the thirteenth highest emitter of greenhouse gasses in the world.
It is therefore important that the focus within our country should be on increasing renewable energy. This is imminently doable as the renewable energy potential in South Africa is very high (Department of Energy (DoE), 2012), as can be seen from the solar resource. With more than 2 500 sunshine hours per year, South Africa has the perfect climate for generating solar energy; in fact, one of the best in the world (Gauche, Meyer, & Brent, 2013).

The South African government has outlined its commitment to develop an enabling framework to help the South African renewable energy industry to operate and grow as stated in the White Paper on Renewable Energy Policy (Department of Minerals and Energy (DME), 2003). As a result, the Integrated Resource Plan (IRP) for Electricity was initiated by the Department of Energy (DoE) in 2010. The IRP sets out the new build plans for South Africa's future diverse electricity supply from 2010 to 2030 and set the groundwork for the REIPPP-Programme (Department of Energy (DoE), 2011).

However, one aspect which has put a hold to the renewable energy IPP Procurement Programme was that in the White Paper of 2003, renewable energy technologies were seen as not fully developed nor in a position to be commercialised, as costs tend to be too high (Department of Minerals and Energy (DME), 2003). Similarly, Walwyn & Brent (2015) mentioned that until as recently as 2012, surveys have placed renewable technologies as more expensive when compared with nuclear and fossil fuels.

Fortunately there is a shift in both accepting renewable energy technologies as well as a drop in the price of the technologies which makes it **economically** much more viable and competitive (Eberhard, 2014) (CSIR, 2015).

In the 2014 report on the South African IPP Procurement Programme, Eberhard (2014) stated it is judged to be highly successful by the program stakeholders. This was also confirmed with the DoE report, *State of Renewable Energy in South Africa*, in 2015 (Department of Energy (DoE), 2015).

One of the successes of the Government's strategy is the focus on **social** equity within a 50 km radius around renewable energy power plants (Department of Energy (DoE), 2015). Eberhard (2014) indicated that this benefit from a project's revenue implies that the IPP Procurement Programme has the potential to leverage the **economic, social and local** development of such a community. An example of social and local development is the implementation of the learning material of the Renewable Energy Schools' Programme in some of these communities and that some of the participants of this research are from these communities.

To date, four tender rounds have taken place in the REIPPP-Programme allocating in total 92 projects to IPP's with a generating capacity of 6 300MW (Department of Energy (DoE), 2015). Whilst a fantastic success for our country, it also shows that South Africa's renewable energy sector can provide the rest of Africa with a platform for the development of this industry, as South Africa's industry is the most matured at this stage (Raw, 2015).

The World Wide Fund's (WWF) viewpoint is that the South African future needs a developing **economy** and society, and this can be met by a broad renewable energy base (World Wide Fund (WWF), 2014). It is therefore clear that switching to more renewable energy not only addresses the environmental challenge of climate change, but also addresses the social and economic challenges we are facing within South Africa and in other parts of the world.

2.2.7 Education in renewable energy

To achieve sustainable development it is therefore important that the South African public needs to be educated on climate change and renewable energy. This is also in line with some of the key objectives of the Government's enabling framework, namely to raise public awareness on renewable energy and to educate the public of the benefits and opportunities in renewable energy and how it can counteract climate change.

The higher education environment serves as an integral mechanism to achieve these objectives. CRSES at SU acknowledges their role in educating the public, both at a school-going level as well as

to university students. CRSES therefore presents postgraduate research in renewable energy and also developed the Renewable Energy Schools' Programme, in order to meet the education need.

In response to ESD, CRSES realised that the topics of climate change and renewable energy have recently become mainstream and form part of the school curriculum. Unfortunately, this implies that most teachers at secondary school level have to teach topics with which they are not (necessarily) familiar. As a result, a research-based set of Learner Teacher Support Material for high school teachers on renewable energy was developed. This is to empower teachers to effectively facilitate learning about non-renewable and renewable energy, broaden the knowledge base of teachers on climate change and renewable energy, and to provide them with appropriate subject materials to ensure effective implementation in classrooms.

For the purpose of this study Learner Teacher Support Material (LTSM) will be referred to as learning material.

2.3 Education for Sustainable Development

Early general conservation education expanded into environmental education, which was then extended by the United Nations to become ESD. It is this ESD on which I focus this study. The research argument being that in order to achieve sustainability, we need to change our current patterns of energy use.

For the purpose of this study, ESD will be discussed in relation to the use of renewable energy learning materials by teachers, and determining whether the use of the learning materials adequately provoked change in energy use patterns in South Africa for future sustainability.

With the emergence of more data on climate change, ESD emerged as a global concern. The United Nations Educational, Scientific and Cultural Organization (UNESCO) developed the Global Action Programme (GAP) (UNESCO, 2014) as an action plan for learning strategies in the following five priority areas:

1. Mainstream ESD into education and sustainable development policies
2. Transforming education and training by integrating sustainability practices into these environments
3. Building the capacities of educators and trainers
4. Empowering and mobilising youth by generating ESD actions among the youth

5. Accelerating sustainable solutions at a local level, by encouraging local communities and municipal authorities to develop community-based ESD programmes

In line with this, the Minister of Basic Education, Minister Motshekga committed at the 2014 UNESCO World Conference on ESD in Japan, to reinforce the progression of the five priority areas of the GAP into the Department of Basic Education's framework (SA Government, 2015).

2.3.1 Education for Sustainable Development in CAPS

The National Climate Change Response White Paper released in 2011 by the Department of Environmental Affairs (DEA) set out criteria on how to address climate change. The paper emphasized that the inclusion of climate change education should become part of ESD in the South African curriculum (Department of Environmental Affairs (DEA), 2011). As a result climate change and renewable energy was included as part of various subjects, as can be seen in Table 1

Table 1: Renewable energy in the CAPS

Natural Science	**Grade 7**	**Energy and Change (CAPS p.31)**
	Topics	**Investigations**
2 weeks	The national electricity supply system Renewable and non-renewable sources of energy	Compare the advantages and disadvantages of non-renewable and renewable energy sources.
Natural Science	**Grade 9**	**Energy and Change (CAPS p72)**
Term 3: National electricity grid	• Power stations burn coal to heat water to create steam to drive turbines which drive dynamos (generators) • Alternative sources of energy, besides coal, that can be used to drive dynamos: wind, waves in the sea, falling water, sun heated steam, nuclear fission	Research alternative sources of energy that can be used to drive dynamos for the national grid. Evaluate these in terms of sustainability and environmental impact.
Costs of energy from electrical systems		Calculate the energy consumption of different appliances
Social Science	**Grade 9**	**Geography (CAPS, p32)**
Term 4 : Resources use	Uses of natural resources: • Renewable and non-renewable • Effects of unwise use of resources	
Social Science	**Grade 10**	**Geography (CAPS, p21-22)**
Term 1: The composition and structure of the atmosphere	Heating of the atmosphere, global warming and the greenhouse effect and the impact of climate change. Link to resource use and to projects at school that have a CC focus.	
Term 4 (p26) Water Resources	The World's Oceans • Oceans as sources of oxygen, food and energy;	
Social Science	**Grade 11**	**Geography (CAPS, p 36 -37)**
Term 4: Resources and sustainability: soil, energy	Resources and Sustainability • Using resources • Soil and soil erosion • Conventional energy sources and environmental impact • Non-conventional energy sources • Energy management in South Africa • Geographical skills and techniques • Geographical Information Systems (GiS)	The entire terms work again relates very closely to resource use. Many opportunities for the application of creative teaching methods which you can link to investigations for your school
Physical Science	**Grade 10**	
Optical phenomena and properties of materials	Photoelectric-effect use as an enrichment assignment	
Physical Science	**Grade 11**	
Electromagnetism	Faraday	

Unfortunately, in some cases, it was only included as enrichment knowledge or was optional and therefore learners are not necessarily examined on it.

The discussion that follows is a brief look into the development of ESD in the CAPS and how learning material was developed and is used by teachers.

ESD developed from conservation awareness in the 1970s to environmental education processes of inquiry and problem solving in the 1980s. During the 1990s there was a stronger move to participation in sustainability practises and currently, we find that ESD is more focussed on developing skills, identity and knowledge (O'Donoghue, 2014).

From 1980 to 1999, the focus on Environmental Education (EE) and ESD in South Africa was found in the overall curriculum as a concern for raising awareness, providing nature experiences and including new environmental knowledge. This stimulated the development of EE and ESD learning material for teachers (Glover, 2006). Curriculum 2005 (C2005) and Outcomes Based Education (OBE) brought environmental learning as a phase organizer across different learning areas, but this cross-curricular approach did not meet the aim of deepening knowledge (Schudel, 2010). The importance of the inclusion of new environmental knowledge as part of the curriculum is further emphasized by Tshiningayamwe (2011), who notes that learners must understand that there is a reciprocal influence between the environment and themselves and therefore they have a responsibility towards the environment.

Thus with the establishment of CAPS in 2012, it was noticed that, with ESD as part of the subject curriculum, ESD emerges in the development and understanding of knowledge as mentioned by O'Donoghue (2016) and will produce learners that will have knowledge on environmental and sustainability issues (Songqwaru, 2012). This focus on key concepts and content knowledge is evident in and practically supported by the renewable energy materials.

This inclusion of ESD in the CAPS posed two problems, namely:

i. Teachers had not received the necessary education and training on the new environmental knowledge which was already part of the CAPS syllabus.
   The number of school curriculum changes implemented by the Department of Education from 2005 to 2016 problematizes this situation even more. This lack of necessary knowledge is confirmed by the South African Eco-Schools evaluation of 2007-2008 (Rosenburg, 2008). As a result, CAPS (2012) addressed the lack of knowledge on the environmental issues and sustainability in most subjects. But seeing that this topic is new to teachers and possibly was not addressed during their studies, the teachers find it challenging (Fundisa for Change, 2013). These challenges resulting from a lack of training were confirmed during feedback given in the renewable energy workshops (4.4.2, Flash drive Appendix 16, L96).
ii. The fast rate at which knowledge develops, especially in the fields of climate change and environmental issues, poses another challenge in the designing of a responsible curriculum which reflects the vast body of knowledge of this subject field.

This aspect of knowledge development in terms of climate change could be seen in the Stockholm Resilience Centre's report on Planetary Boundaries mentioned earlier (Steffen et al., 2015) as well

as the effect that the decline in cost on renewable technologies has (Walwyn & Brent 2015) not only on the industry but also on the acceptance from the public of renewable technologies.

In the draft report, from the United Nations Framework Convention on Climate Change (UNFCCC) done by the Environmental Learning and Research Centre (ELRC) at Rhodes University, on the implementation of education, training and public awareness activities on climate change in South Africa, a third challenge seemed to arise with the inclusion of ESD in the curriculum. It seems that climate change is not clearly defined in the curriculum and this is reflected in school text books. Then teacher education material becomes essential to empower teachers with sound content knowledge on climate change. A further problem arises in that content developers write learning material on climate change from their own point of view and preferences, not necessarily based on the latest scientific evidence. Therefore the report recommends that learning material must be aligned with a conceptual framework for climate change education which is agreed upon nationally (Lotz-Sisitka, Gumede, Mandikoza, & Ward, 2016).

In the GEM report (2016), a close connection is also made between quality education and ESD and that if we want to have and leave a healthy planet for generations to come, our education systems need to reflect this.

This is emphasized by the UNFCCC draft report (2016) on climate change education in South Africa which states that climate change education and training must be seen as an essential criteria of quality education and not as a side issue (Lotz-Sisitka *et al.*, 2016).

2.3.2 The development of learning material in Education for Sustainable Development

Russo and Lotz-Sisitka (2006) emphasized the important role that research plays in the development of learning content, the design, adaptation and use of learning material. The authors also pointed out that different ways of designing learning material will influence different opportunities of learning. Therefore, thorough research on the topic of ESD and renewable energy should be part of the planning process.

In addition to this, Ensor *et al.*, (2002) and Onuoha-Chidiebere (2011) note that the development of learning material should enable teachers to structure their lessons, to obtain various lesson objectives, to enhance their teaching strategies and to ensure effective assessment. To this Mbanjawa (2002) added that learning material should contribute to the conceptual knowledge of teachers and the abilities of learners to find meaning.

The development of sound learning material for ESD and effective teaching strategies will benefit not only the learner's knowledge on this subject but it will also stimulate the learners' exploration and critical thinking (North America Association for Environmental Education (NAAEE), 2004).

Besides ESD, learning material must attempt to provide learners with new information on a specific topic. Russo and Lotz-Sisitka (2006) suggest that the question should be asked what the learning material encourages? Is it critical thinking, investigation into the topic or critical assessment of the situation of the topic?

The NAAEE (2004) has generated guidelines for excellence in the development for ESD material, which are:

- The material should be fair and accurate in reflecting the diversity of environmental perspectives and issues
- The material should support awareness and in-depth understanding of the natural and built environment
- The knowledge gained should build skills to address environmental issues
- The knowledge gained should promote an action orientation
- The material should promote sound teaching methods for ESD
- The material should be designed well and easy to use

(NAAEE, 2004)

The *Education 2030 Framework for Action,* which is reported on in the GEM Report, is to further progress towards the SDG 4 of quality education; Goal 4.7 states that by 2030 mainstream education will have to provide the knowledge and skills that are necessary for all learners to further sustainable development (GEM, 2016).

2.3.3 The use of learning material in Education for Sustainable Development

A number of readings agree that the effective and successful use of environmental learning material depends on the following aspects:

- Links to the curriculum
- Relevant subject content
- Support for teachers in the use of the learning material
- Appropriate language use

(Russo & Lotz-Sisitka, 2006) (Glover, 2006) (Riet, 2012) (Van der Merwe, 2011)

Two other aspects added by Riet (2012) are the teacher's ability to mediate learning, and learners' competency levels. Riet is also of the opinion that teachers have different approaches to facilitation and that learning material must be adaptable to accommodate this. The author further indicates that the differences in learner abilities must be taken into consideration when choosing how to use learning material and the content must be meaningful for learners (Riet, 2012). This is confirmed by Russo and Lotz-Sisitka (2006), that learning materials can provide different learning opportunities through the influence of different learning processes.

Another point made by the authors is the necessity for an ongoing reflexive review of the development and use of learning material, as well as specified feedback from teachers on how they have used the material and how the materials might be usefully adapted (*ibid*.).
In terms of the renewable energy learning material, this reflexive review will be reflected on later in the study along with the influence that the reflexive research process had on the development of the learning material.

From the above, it is evident that a lot of research has been done on how to *develop* learning materials and include content knowledge, but little is said about learning and *how learning* is taking place.

The literature on ESD learning materials reviewed for this study is characterised by a lack of detail on how the materials shaped or contributed to learning. One of the key concerns of the study was, however, to be able to analyse and deduce something about the renewable energy materials and ESD. To this end the review was directed to literature on learning in search of a perspective to probe the relation of the materials use to learning.

2.4 Anne Edwards's learning task sequencing

The inclusion of ESD is achieved by teaching new environmental knowledge in all subjects. This makes it a challenge to be specific about ESD processes in materials designed to meet the teacher and curriculum goals in relation to the curriculum. Environment and sustainability matters thus need to be presented in such a way that learners will internalise concepts and deduce meaning that is relevant in the context of their daily and future energy use.

The idea of learning task sequences that builds on one another makes it possible for leaners to become familiar with new content, ideas and concepts in such a way that it allows them to internalise the content and to reach specific knowledge goals. A variety of learning sequences are available, but the one reviewed for use in this research is the Anne Edwards learning task

sequence. The research focus on how teachers use the renewable energy materials with the Edwards learning task sequence framework providing a lens for analysing how the learning material is used to support learning interactions in the classroom, and how the material use is mediating learning interactions and understanding of the topic of current and future energy options.

A review of the Vygotskian-based learning task sequencing work of Edwards enabled me to look at learning processes associated with the patterns of materials use in a classroom context, and how learning is being mediated by the teachers.

2.4.1 Vygotsky informed the development of the learning task sequence

Vygotsky's view that learning is centred on externalisation and internalisation in order for a learner to develop their own learning processes instilled in Edwards a renewed interest in the importance of the emergence of a learner's self-regulation, and agency in the acquisition and use of knowledge. According to Edwards, good teaching is not only when a teacher is knowledgeable about the subject and uses the best teaching strategy to impart the knowledge, but it also takes into account the learners' understanding of and the ability to engage with the learning material to take responsibility for their own learning (Edwards, 2014).

Vygotsky's theories of scaffolding, semiotic mediation and Zone of Proximal Development (ZPD), emphasize different processes that take place in learning transactions (Daniels, 2008). This point allowed the framing of the learning theory to be used in the analysis of the task sequences and the associated learning processes mediated by the teachers in their lesson accounts and associated learner's work.

Here scaffolding is a process through which learners are initially guided to develop concepts and skills. O'Donoghue (2015) mentions that the learning expands from acquisition through participation in work with the teacher and texts into learning activities that are more learner-led and reflexive. In addition to this Smidt (2009) describes the term scaffolding as moving from the performance level to the potential level. In this case, the learning task sequence gives the support or structure that the teachers need to support the necessary learning and meaning-making to activate the child's creativity and agency with the renewable energy materials.

John-Steiner and Mahn (1996) noted that sociocultural approaches to learning and development were first described by Vygotsky and his collaborators. They stated that human activities are mediated by different mediation tools, for example language and other symbol systems and can

be best understood in their cultural context and historical development. Examples given by Vygotsky on mediation tools in school learning were: "language; various systems for counting; mnemonic techniques; algebraic symbol systems; works of art; writing; schemes, diagrams, maps and mechanical drawings; all sorts of conventional signs" (Daniels, 2008, p. 7). This research focus enabled me to give attention to learning associated with how the mediation tools in the renewable energy learning material is used by teachers in task sequences. The mediation tools consist of a DVD, PowerPoint presentations, assignments, posters, a teacher's manual and subject-specific activities.

Daniels states that the concept of Zone of Proximal Development (ZPD) was hypothesised by Vygotsky as a devise for explaining the way in which social and participatory learning takes place as an expansive learning process (Daniels, 2008, p. 76). In addition to this John-Steiner and Mahn (1996) described the ZPD in a learning process as the distance of the levels of development where the learner performs alone and independently, and against this, the potential level of development possible with assistance from an adult or more capable peer. It could therefore be argued that ZPD is a proposition which suggests the level of possibilities or potential of development of a learner in a mediated process of learning.

Two aspects of Vygotsky's notion of a zone of proximal development are significant in the Edwards task sequence model. Firstly, the development of a learner with the guidance of an adult teacher or in collaboration with more capable peers who understood the concepts being taught and secondly, the notion that in learning, instruction moves ahead of development (Daniels, 2008).

Anne Edwards used these Vygotskian concepts of scaffolding, semiotic mediation and ZPD in the framing of the four quadrants in her task sequencing model for classroom learning. She argued that if the sequencing was in a lesson, scaffolding would enable mediated learning to take place where the learners would journey in meaning-making to take control over their own learning processes. Here the sequences of learning instruction would precede development but development could enable learners to take control of their own learning and use their knowledge. The learner-led agency explored by Edwards and the reflexivity associated with this were key for ESD as critical processes of learner-led change.

2.4.2 Learning task sequencing

The learning task sequence is developed as an open-ended progression of learning tasks differentiated into four quadrants. The task sequence design focuses on the actions taken by the teacher in these tasks and the learners' responses. It also allows for an examination of patterns of lesson planning and delivery. Its use as an analytical tool allowed the research to begin to map out and review how use of the materials reflects learning sequences and thus to shed light on learning outcomes (Edwards, 2014).

The four quadrants focus on the following aspects:

In Quadrant One (Q1) knowledge is being displayed by the teacher or more expert learner in the selective use of the learning materials. Here the teacher selects and works with the materials to model and instruct key concepts. This is achieved through the use of different mediation tools, for example language, text and multimedia on a specific topic.

In Quadrant Two (Q2) more tightly structured tasks are given to the learner as activities by the teacher. These demand engagement with key concepts (substantive knowledge) and ways of enquiring (syntactic knowledge), for example the energy audit or measuring electricity use in their school or homes.

In Quadrant Three (Q3) more open tasks are given, for example, investigations and research on renewable energy technologies, which enable learners to apply key concepts and ways of enquiring. Here tasks may be phrased as an open-ended question for learners to research. This is where participation and enquiry will take place and where the learners take that inquiry into contemplating future sustainability.

In Quadrant Four (Q4) knowledge is being displayed by the learner through summative assessment, for example writing a test on renewable energy concepts (Edwards, 2014). Edwards is careful to specify that her task sequencing model of process is open-ended in that teachers can start a learning sequence in any quadrant and move through in any order. For example, a learning challenge can open with an enquiry where learners use what they know to undertake and scaffold enquiry tasks into which a teacher might insert activities to clarify concepts and also mediate learning with direct inputs.

In Figure 1 O'Donoghue graphically displays how he used the Edwards learning task sequence in ESD, to describe knowledge acquisition to reflexive problem solving actions.

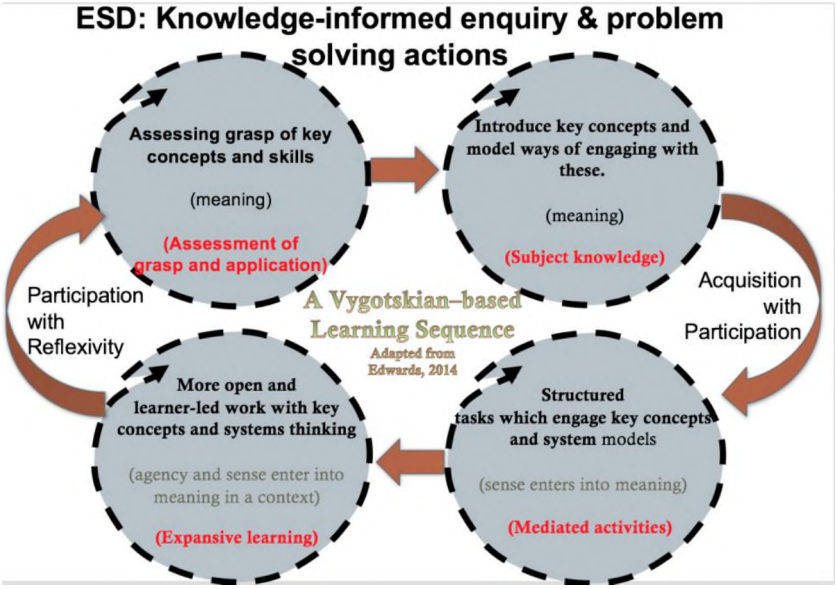

Figure 1 ESD: Knowledge-informed enquiry and problem solving actions (O'Donoghue, 2015)

This implies that the learning task sequence allows for an analysis of the classroom learning process through a mapping out of processes of knowledge acquisition (internalisation, mostly found in Q1 and Q2) and use (externalisation, mostly found in Q3 and Q4) (O'Donoghue, 2015). Key aspects of the tasks are the amount of structure provided and the amount of control that allows learners to take over their own learning, and develop higher order thinking skills (Edwards, 2014).

Edwards (2014) notes that the task sequencing can take place in any order and that the model is a potential way of how learners can be developed and how learning can be promoted. For example, as noted above, sometimes the teacher will start a sequence in Q3 and move back to Q1 or move from Q3 back to Q2 to clarify concepts. In short, it needs to enable a learner to discover or learn something; for them this applies not only for the subject matter but also for developing their own learning skills.

If the renewable energy materials are going to be effective, then the teachers need to be able to teach with them,-set up activities, set up projects where the learners are going to take the lead and to test learners knowledge on the content.The mapping of this level of detail using the learning task sequence to probe lesson progressions allowed the researcher to identify some of the learning sequences evident in how teachers are teaching the topic and to look for evidence of how learners are able to apply their new knowledge in renewable energy.

It is therefore possible to say that desirable environmental learning or the way that learning should be supported in the class for learners to learn about renewable energy should include all four quadrants that Edwards mentions.

2.5 Conclusion

From this review of the literature it is clear that renewable energy has been established as a mainstream energy source not only in South Africa but worldwide. Here the design of the materials has been framed for the transitioning to an alternative energy generation and their use in this way can make a contribution to the SDGs. To realise this, learning material must be providing teachers with good, sound knowledge on renewable energy as this topic has been included in the South African school curriculum.

To examine the effective use of the learning material for ESD, the Vygotsky-based, learning task sequencing work of Anne Edwards was used to examine the learning sequences in a classroom context to provide some insights on the effective mediation of learning by the teachers using the materials. The important thing is the balance between the teaching of the knowledge, the exploration of the concepts and the follow up action. The action step taken will enable the study to be classified as an ESD project, due to the Q3 quadrant—the knowledge and mastery of concepts. This raises the question—did the material enable teachers to teach by presenting knowledge, by tasking concept-clarifying activities, so that learner-led inquiry or action taken was facilitated?

This implies that insights on the effective use of task sequencing will provide patterns of lesson planning and delivery. Task sequencing will thus be used as an analytical lens for providing insights on the effective use of learning materials to achieve the CAPS learning outcomes in relation to renewable energy.

Chapter 3 Research Methodology

3.1 Introduction

In this chapter the research process is discussed. This includes the different research activities that were used to gather the data to answer the research question on how teachers are currently using the renewable energy learning materials to support learning, and what value was added to their teaching and learning practices through the learning materials. Insights on this added value and patterns of use to support learning will influence the updating and improvements of the material.

The research orientation, design and methods are directed by the research question and goals. The research orientation of the study was undertaken as an interpretive study based on evidence from the historical review and evidence received from participating teachers in the five case studies. The research is undertaken around qualitative data (reported evidence) on how the materials were used in classrooms and accounts of the value that was being created. The evidence on patterns of learning task sequencing and value creation will be used to inform the planned update of the learning material and future teacher workshops.

3.2 Research methodology

The research methodology is the contextual framework that guides the decisions (Kara, 2015) made in this study, and which in this case is a qualitative research orientation embedded in an appreciative inquiry.

3.2.1 Research orientation

A qualitative study endeavours to understand how humans conduct themselves in a natural setting and their social interactions towards a specific challenge or problem. The process of collecting evidence normally entails questions and methods that are determined by the study. Furthermore the research method develops inductively, meaning that the theory emerges from the data (Creswell, 2014). In this study the researcher will look for evidence which relates to the learning task sequence framework in order to understand what patterns of use were developed by the teacher. According to Maxwell (2008) qualitative research should be seen as a circular process, meaning that the researcher reflects on evidence and returns to the data more than once for interpretation. Qualitative research also suggests the measurements of the characteristics of something; in this case, to understand how teachers used the renewable energy learning material.

3.2.2 An appreciative inquiry approach

To determine what value is created for teachers by using the renewable energy learning material, an appreciative inquiry approach was followed. Appreciative inquiry allows for an abductive analysis of the value that was created for teachers on the one hand and for further development of the materials on the other. The reason for this is because the focus of an appreciative inquiry helps to determine what is effective and works (Hammond, 2013), rather than to focus on identifying problems. An appreciative inquiry is thus an approach to determine what value was added for teachers with regards to their teaching and learning practices by using the learning material and not to focus on problems they experienced when using the material. In other words the focus is a generative process, centred on how the materials are used and whether new possibilities are opening up in order to enhance and enrich the learning materials. The work has been centred on appreciative accounts of the teachers of the materials used, a technique described by O'Donoghue (2015).

To generate appreciative accounts of how the learning material were used by the teachers, the researcher worked with the participating teachers to frame a series of research instruments, for example a questionnaire, teachers' accounts of their lessons, lesson plans, electronic interviews and evidence of learners work. Collaboration had been built up over the last few years of sustained interaction with the teachers so an appreciative and collaborative approach worked well for teachers who provided data on usage or elected to participate in the research process with more depth detail on lesson planning and classroom use.

3.3 Research participants

For the successful dissemination and implementation of the learning materials, teacher workshops have been presented since 2009 in six provinces, by using the existing school networks from the Department of Basic Education, the *Wildlife and Environment Society of South Africa* (WESSA) Eco-Schools programme, Science Centres, Green Cape, Independent Power Producers and the Fundisa for Change programme. From the start, the compiling of a database was part of the endeavour in the form of contact details, workshop evaluations and follow-up surveys completed by the teachers. The five research participants in this study were teachers who are on the database and who participated in one of the workshops over the past few years.

The yearly email survey conducted at the end of 2015 called for teachers who were willing to participate in the research. These teachers were then contacted through email where the depth of

the research process was expanded and explained. Ten teachers indicated willingness to take part in the study, but only one sent sufficient data on how she used the materials.

In 2016, teachers who participated in workshops during the year were asked to take part in the research and to submit responses with the necessary detail on how the materials were used.

The final selection of five case studies was as follows:

- Case A responded to the 2015 email survey and confirmed her willingness to participate.
- Case B took part in a workshop at the beginning of 2016 and was asked to participate.
- Case C and D were part of the Teacher Professional Development programme in the Northern Cape in March 2016 and were asked to participate.
- Case E did the workshop in 2014 and enquired about the learning material at the beginning of 2016; she was asked to participate.

3.4 Data generating methods

Ongoing research was part of the schools' programme since its inception in 2008. Different data generating methods have been used over the years, which include a pilot study, a telephonic survey, workshop evaluations, and email surveys conducted at the end of each year since 2013.

This appreciative review on how the materials are used by teachers was undertaken in two stages:

Stage 1: Historical review of 2008 -2016, detailed in Chapter 4

Stage 2: Five case studies of patterns of use to support learning, detailed in Chapter 5

The historical data from the project reviewed in Chapter 4 enabled the researcher to read the case evidence documented in Chapter 5 against the expanding materials and activities within the emerging learning networks. The purpose of the study undertaken in these two stages was to review evidence of patterns of use so as to get some insights into how the learning material supports learning and how it might be improved to provide the necessary knowledge and skills about energy use and future sustainability.

For the participants to take part in the research they had to sign the letter of consent. The methods used in this study to generate evidence on material used were questionnaires, document analysis of lesson plans, learners' work, and follow-up interviews.

Practical steps involved in this appreciative evaluation research process were to:

- Identify teachers who were willing to participate

- Design a questionnaire to determine the patterns of use
- Analyse received documentation
- Conduct follow-up interviews

3.4.1 Review survey

The yearly email survey, undertaken at the end of each year, was conducted to determine whether the renewable energy learning material was used by the teachers during 2015. The intention of the survey was to sample from the 'large population of interest' (Kelley, Clark, Brown, & Sitzia, 2003) and to draw conclusions from this wider population (Creswell, 2014).

Two aspects play a role in the timing and manner of the survey. Firstly, renewable energy forms part of the curriculum during the third and fourth terms in Natural Science (grade 9) and Geography (grades 11 and 12), therefore the survey can only be sent out at the end of the year. Secondly, from previous surveys sent to teachers, it was clear that the best response to the survey was when the survey was kept short as most of the responses are done on mobile phones because teachers receive their emails on their mobile phones.

The survey was sent out to all teachers on the database in December 2015 as referenced in Appendix A. The survey consisted of three short questions in order to determine for what subjects and for which grade the materials were used. A fourth question was added to determine whether there were teachers who were interested participating in the research. The survey feedback is summarised on a spreadsheet in Appendix B.

3.4.2 Questionnaire with participating teachers

The teachers who indicated that they are willing to participate in the research and who signed the letter of consent each received the questionnaire. The purpose of the questionnaire was to generate more detail on the use of the materials, to use the information to inform the contextual profile and to determine the value that was added for teachers by using the materials (See Appendix C).

Different types of questions were used in the questionnaire. It contained categorical questions which included closed (yes/no) questions to determine specifically which components of the materials were used, for example the PowerPoint on solar energy or the posters, and multiple choice questions where the teacher had to indicate how learners responded to a certain aspect of the material, being poor, average or good.

To determine the contextual background of each participant, the questionnaire included open questions in question 1 and 2 and closed (yes/no) questions in question 7. These informed the context of the school in which the material was presented as well as whether the material complied to certain expectations.

For most questions, the option was given to provide comments especially in terms of the value that was added. These comments were analysed abductive by looking for themes that emerged from the feedback to determine the value that was added to teaching practices.

3.4.3 Document analysis

Document analysis was used to analyse patterns of use from documentary records provided by teachers. This served to provide contextual as well as historical data (Cohen, Manion, & Morrison, 2007) on the use of the materials. The documents which were analysed in this study were the teacher's account of their lessons, lesson plans, electronic interviews and learners' work. These documents were analysed by the researcher for implicit and explicit task sequencing along with evidence of value that was added to teaching practices.

In this case the researcher is aware of the fact that some of the documents are written as an interpretation by the participant of the events on what happened and can therefore be not an exact account of what happened in the classroom *(ibid.)*.

3.4.4 Follow up interviews with participating teachers

Interviews allowed participants to give their interpretation and understanding of a specific situation and to voice their point of view. An interview differs from a normal conversation in the sense that it has a purpose, it is normally question-based and it is constructed and planned beforehand (Cohen et al., 2007).

Follow-up interviews with teachers were electronic, to clarify the meaning of the feedback received and thus ensuring that the original intentions were correctly understood by the researcher.

3.5 Data management

In line with Creswell (2009) data were organised for analysis in order to get an overall impression of the information provided. The researcher thus read through all of the material to think through the overall meaning and then started the analysis by developing categories to code the information provided. It was important to identify themes and to search for theme connections.

This process culminated in a discussion on the data in a research report and an interpretation of the information generated using the research instruments.

All the data mentioned in section 3.4 were indexed and an inventory was created, as shown in Table 2, where each document and participant was given a code. Each teacher was handled as a case, thus teacher A became Case A. The documents associated with each participant were then coded accordingly, for example Case A's (CA) account of lesson (AL) became CAAL. The date on which the documents were received was also documented.

Table 2: Inventory of data produced, showing the index given to each component

	Confirm analysis	Letter of consent code LC	Question-naire Code Q	Lesson Plan Code LP	Teacher account of lessons Code AL	Learners Work Code LW	Interviews Code I
Case A Code: CA	2016/11/03	CALC 2016/03/07	CAQ 2016/11/06		CAAL 2015/12/06	CALW 2016/11/03	CAI1 2016/11/03 CAI2 2016/11/06
Case B Code: CB	2016/09/19	CBLC 2016/06/22	CBQ 2016/06/22		CBAL 2016/06/23	CBLW 2016/07/04	CBI 2016/11/08
Case C Code: CC	2016/09/22	CCLC 2016/07/29	CCQ 2016/07/29	CCLP 2016/03/31	CCAL 2016/07/13		CCI1 2016/08/10
Case D Code: CD	2016/10/12	CDLC 2016/07/29	CDQ 2016/07/29	CDLP 2016/07/19		CDLW 2016/07/19	CDI1 2016/10/31
Case E Code: CE	2016/10/16	CELC 2016/02/20	CEQ 2016/08/04		CEAL1 2016/08/04 CEAL2	CELW1 2016/09/16 CELW2	CEI1 2016/08/04 CEI2 2016/09/06 CEI3 2016/10/14 CEI4 2016/11/08

3.6 Data analysis

For the analysis of the data, two phases were used:

Phase 1: To determine the patterns of use through the Vygotskian-based learning task sequence of Anne Edwards.

Phase 2: To determine the value that was created for teachers through the use of the learning materials.

3.6.1 Phase 1 analysis: Anne Edwards learning task sequencing

The Vygotskian-based learning task sequence by Edwards (2014) was used as an analytical lens for mapping the learning tasks and task sequencing in the current teaching practices. This was done by

analysing the documents to determine the activity, the learning process and the quadrant in which it took place.

The study was informed by a Vygotskian perspective; therefore the analyses of the documents took place by looking for semiotic mediation, ZPD and scaffolding. For the purpose of this research, semiotic mediation will be to determine how the learning materials were used as tools of mediation. ZPD will be determined whether there were instances of development that took place with the assistance of the teacher or more capable peer and where instruction moved ahead of development. Instances of scaffolding will be determined in processes where learners developed higher order thinking skills and took control over their own learning through tasks given by the teacher.

The Edwards (2014) task sequencing framework for classroom learning is developed as an open-ended progression across four quadrants. The four quadrants, displayed in Table 3, focus on what the teacher or more expert learner was doing compared to what the learners were doing, and how this related to the task sequence quadrants. The table can be viewed in Appendix D: The Edwards Learning Task Sequencing. The activities reflected in the documents received from the teachers were analysed using the four quadrant model as follows:

Table 3: Anne Edwards's learning task sequence

<table>
<tr><td colspan="2">Quadrant 1
Knowledge is displayed by the teacher or more expert learners as they model and instruct key concepts.</td></tr>
<tr><td>What the learners do:
• Engage through meaning making.
• Respond to the teacher's questions.</td><td>What the Teacher / Expert learner does:
• Introduce key concepts and revisit what is already known.
• Help learner recognise and fill knowledge gap.
• Imitation(Vygotsky)
• Demonstrate knowledge
• Diagnose the interpretation by the learners
• Introduce the learners in using the language and other forms of the knowledge displayed.</td></tr>
<tr><td colspan="2">Quadrant 2
Tightly structured tasks which demand engagement with key concepts (substantive knowledge) and ways of enquiring (syntactic knowledge)</td></tr>
<tr><td>What the learners do:
• Show thinking skills and respond to the task demands, taking control and exploring what they can do.
• Scope the tasks, allocate time, and identify needed resources.
• Self-assess against criteria – referring to knowledge and strategies used.</td><td>What the Teacher / Expert learner does:
• Teacher's formative assessment of Q1 indicates that learners are starting to make the connections between already known and new.
• Individual, paired or grouped tasks are given.
• Teacher gives actively formative feedback on both the use of knowledge and the organization of learning.</td></tr>
<tr><td colspan="2">ZPD takes place in Quadrant 2 and Quadrant 3. Semiotic mediation takes place by the use of different mediation tools, for example language or readings. Safe places, mistakes can be made, misunderstandings revealed and risks taken. Acquire and use, internalise and externalise, substantive and syntactic knowledge acquired and used. Learners develop higher order thinking skills and taking control over their own learning through tasks given by the teacher.</td></tr>
<tr><td colspan="2">Quadrant 3
More open tasks which enable learners to apply key concepts and ways of enquiring. Task may be phrased as an open-ended question for learners to research.</td></tr>
<tr><td>What the learners do:
• Open-ended, problem solving activities.
• Take control of the knowledge they have just grasped and use it to solve problems.
• Show agency</td><td>What the Teacher / Expert learner does:
• (Require high levels of teacher subject knowledge.)
• Knowledgeable resources respond to students questions. Only intervening if learners are experiencing real difficulty.</td></tr>
<tr><td colspan="2">Quadrant 4
Learners display their understanding and knowledge through summative assessment</td></tr>
<tr><td>What the learners do:
• Complete the summative assessment task.
• Master the tool of uncertainty.</td><td>What the Teacher / Expert learner does:
• Summative assessment of learning
• Gives grades for the display of new found understandings.
• Jumping point for new cycle.</td></tr>
</table>

The results of the analysis of the five cases using the framework outlined in Table 3 (above) can be seen in full in Appendix G - K. Table 4 is an example of how the analysis was ordered and reported as data for the study.

Table 4: Patterns of use by teachers

Document Case A Account of Lessons (CAAL) Line (l) Activity	Code Line (L)	Quadrant			Code Line (L)
Activity	**CAAL**		**Learning Task Sequence**	**Value Created**	**CAAL**

3.6.2 Phase 2 analysis: Value creation

An abductive analysis was used to determine the value that was created for the teachers through using the material. These comments were analysed inductively by looking for themes that emerged from the feedback to determine the value that was added to teaching practices.

3.7 Validity and reliability

As convenor of the review process, I had been closely involved with the development of the materials and in the training of teachers. I therefore had to be rigorous in not interpreting the information received from the participants as I understood it to be, rather to listen and record what the respondents were saying. The interpretive review process thus sought to understand the occurrences over a personal reading of what the data was showing (Maxwell, 1992). To ensure that explanatory readings of the date were rigorous, each teacher was sent the analysis to confirm whether the interpretation of their data was correct. The research will be made available to all participating teachers.

Being so closely involved with the materials can cause bias and struggle to remain distanced from the content. I had to be vigilant to avoid this and have managed over the years to develop an objective perspective on the project and how one has to work from what is happening in the contexts of use.

Making use of the Anne Edwards learning task sequence theory to analyse the data and having to explain to teachers that the goal of the research is not to evaluate them, the learners or the materials, but to get an understanding on how the materials were used, also helped me to gain distance from the materials.

3.8 Ethics

This study is in line with the Rhodes University's ethics policy. Bassey describes research ethics as showing respect for democracy, truth and persons (Bassey, 1999).

Cohen suggests that participants have to be informed on their role as participants and the research purposes and procedures had to be set out beforehand (Cohen et al., 2007). To pay respect to democracy, participants who took part in the study were self-elected. They received a written document on what the research would entail and that participation in the study was completely voluntary. Even if they agreed to participate initially, they were free to withdraw from the study at any time without obligation to the researcher. Agreement to participate in the research was explained and those who agreed to participate had to sign a letter of consent. The letter can be viewed in (Appendix E).

To respect each participant as a person, each received a code for using their information. Confidentiality and the right to privacy, dignity, and honesty were maintained, no names or email contact details were revealed in this study.

Truthfulness to the data received was kept at all times. To ensure this, the teachers received their data back to give their further input and feedback on whether the data was interpreted correctly.

3.9 Conclusion

The scope of the data generated included narrative evidence from teachers and a deepening analysis of a sample of teachers where the research extended to evidence of task sequencing in learners' work. The data on teachers' use (reviewed in relation to learning sequences and assessment practices) generated in the study were reviewed to inform an updating of the materials. This included how the resource or any of its contents should be adapted for better alignment with patterns of use. The results will also be used to inform and to improve the teacher professional development workshops and hopefully to achieve better curriculum alignment and ultimately better ESD practices in schools.

Chapter 4 Review of the Historical Development of the Programme

4.1 Introduction

This chapter reviews historical data on four components of the schools' programme:

- **The materials:** The set of materials that was developed and tested to determine whether they enabled an understanding of renewable energy. Two updates have taken place since the development of the initial learning material in 2008.
- **Workshops** that were presented to teachers. Each teacher attending the workshops received a set of the learning material. Questionnaires and surveys were used to generate evidence on how teachers intended to and went on to use the material and this feedback from teachers was incorporated in the improvement of the learning material. Biographical data on all the participants attending the workshops was compiled in order to have the necessary contact details for follow-up information and ongoing networking.
- **Networks** had to be established to have a platform from which the learning material could be implemented and disseminated.
- **Funding**: CRSES, being funded by the Department of Science and Technology (DST) and the National Research Foundation (NRF), allocated a limited amount of funding yearly to the schools' programme; outside funding was required to roll out the programme on a larger scale. The biggest cost is the printing of the material; teachers receive the learning materials for free.

Data on these key components on the development and implementation of the learning material were compiled and will be reported on to reflect the chronology of four phases that characterised the development of the programme:

Phase 1: Development and a pilot study on the effectiveness of the learning material

Phase 2: 2008-2011 Initial implementation of learning material

Phase 3: 2012-2014 Updating and expansion of learning material

Phase 4: 2015-current: ongoing review and expansion

4.2 Phase 1: Pilot project

4.2.1 The learning material

Part of the initial development of the learning material was that two PowerPoint presentations on renewable energy were to be developed. The content of the first PowerPoint presentation was intended to focus on the impact humans have on the planet, not only in terms of water, energy, waste, and habitat loss,-but also the effect that-climate change has on the world, and the drivers that lead to an increase in the greenhouse effect. The second PowerPoint presentation was intended to focus on the different types of renewable energy to counteract climate change. The actual end result for the first PowerPoint presentation was a 12 minute DVD entitled 'Planet Earth, a Living Heritage' and the second PowerPoint presentation developed into eight PowerPoint presentations in both Afrikaans and English.

4.2.2 The value of images

The development of the content started in 2008. At this time the use of PowerPoint presentations was relatively new in schools. It opened up the possibility to make use of explanatory visuals of real examples such as how high wind turbines utilize the higher wind speeds. The learning material leans heavily on the use of visuals as an effective way to mediate learning hence the use of PowerPoint presentations, posters and a DVD: 'Planet Earth a living Heritage'. The end result was a set of renewable energy learner materials which is content based and developed as a story on renewable energy with a strong visual approach.

4.2.3 DVD: 'Planet Earth a Living Heritage'

The aim was to develop a DVD that would improve the understanding among teachers and learners that our planet is endangered as a result of the way we are currently using our natural resources and that we need to lower our impact on our natural environment and switch to a more sustainable way of living.

The DVD was developed in three stages: a background study was done to source the information, the text was refined and shortened and the visuals were added to the text, and the soundtrack was added at the end (on the accompanying Flash drive, Appendix 1).

4.2.4 PowerPoint presentations

PowerPoint presentations were developed to convey the information and contribute to the conceptual knowledge of teachers and the abilities of learners to make meaning from not only the written word but also from the visual images. The aim was to improve the understanding of

teachers and learners that there are alternative energy sources to fossil-based energy sources, which we can use to lower our impact on the planet and become more sustainable.

The PowerPoint presentations were developed in Afrikaans and English and consist of eight topics namely: Energy; Electricity; Solar Energy; Wind Energy; Hydro Energy; Biomass Energy; Geothermal and Ocean Energy; and Energy Efficiency.

Material development is an ongoing dynamic process and is based on the latest research of the field; this can be seen in the continuous development and change of the PowerPoint presentations over the years.

Research was done in the initial development of the learning content which also included a thorough search for visual images for the presentations. A framework was developed for the presentations and built (on the accompanying Flash drive, Appendix 2). The flow of the presentations changed a number of times during the pilot phase in 2008 and again with the updates of the materials in 2012 and 2016.

4.2.5 Teacher's manual

The aim of the teacher's manual was to provide further information to the presentations during lessons. The manual is a complete version of the renewable energy material and contains all the – PowerPoint presentations, extra written information to accompany the presentations, prepared assignments and a glossary for teachers to use.

At the end of Phase 1, the set of learning material consisted of the following:

- DVD: Planet Earth, a Living Heritage
- 8 Modules: Developed as PowerPoint presentations with pictures. Presentations are available in Afrikaans and English and are loaded on flash drives;
- Teachers manual (on the accompanying Flash drive, Appendix 3)

4.2.6 Pilot project of learning material

To ensure the effectiveness of the learning material, pilot studies in three schools were undertaken to determine whether teachers could facilitate effective teaching and learning using the renewable energy material. The results from the pilot study determined how the implementation of the materials was to be done.

The pilot study

To ensure the effectiveness and the quality of the course, a pilot study was undertaken in 2008 in three primary schools. The objective was to determine whether the materials could contribute to the learning experience of grade 7 Natural Science learners. The three schools involved were:

- De Hoop Primary School in Somerset West;
- Somerset West Methodist Primary School; and
- Ikaya Primary School in Kayamandi, Stellenbosch.

The pilot study consisted of the introduction of the learning material in each of these schools during three sessions with the grade 7 learners as a focus. Feedback on the pilot study can be viewed on the accompanying Flash drive, Appendix 4.
The outcome of these pilot sessions was that learning had taken place and the material could thus be used for grade 7 Natural Sciences, but the scope of renewable energy for grade 7 was limited to a small component within the curriculum.

The results obtained from the pilot study thus led to a shift in focus and the implementation and dissemination of the materials was centred on grade 9 Natural Sciences, because the renewable energy component in the curriculum for grade 9 Natural Sciences was more comprehensive than for grade 7 and matched the materials better (on the accompanying Flash drive, Appendix 4, L519-521).

4.3 Phase 2: 2008 - 2011

As a result of the pilot study, the programme then shifted to grade 9 Natural Sciences. This shift started the dynamic process of the ongoing development of the learning material, the building of networks to implement the material through workshops and the sourcing of funding. As the implementing continued and data collected, aspects to focus on for the development for the programme as a whole emerged.

4.3.1 Material development

Between 2008 and 2010, improvements were made to the materials from feedback received from the teachers. In 2009 a glossary was added and the language was edited. Access to an electronic version of the manual and presentations was made available on CRSES's website and the PowerPoint presentations were made more user-friendly and more easily accessible on the website for teachers by adding an index (Flash drive Appendix 5, L4-8)

4.3.2 Workshops

The material had to be distributed to and circulated within the schools and the most effective way of doing this was to present workshops. Table 5 shows the number of workshops that were presented and the number of schools, teachers and students who received the training over the time period from 2008-2011 (Flash drive Appendix 6):

Table 5: Summary of workshops presented from 2008-2011

Year	Number			
	Workshops	Schools	Teachers	Students
2008	9	3	3	
2009	1	18	27	
2010	10	119	117	376
2011	7	72	110	257
2008 - 2011	**27**	**212**	**257**	**633**

At the workshops, the participants attending each received a set of the learning material. They were informed on how the material was compiled, how the content relates to the curriculum and how it could be implemented and used in relation to the requirements of Natural Sciences (Flash drive Appendix 5, L12-15).

A questionnaire was sent out via email at the end of 2009 to determine whether teachers used the materials during that year (Flash drive Appendix 7). Most teachers indicated that they planned to use the learning material in the following year (Flash drive Appendix 7, L6-7). Table 6 shows the number of schools that received the questionnaire; the number of teachers who completed the questionnaire and the number of teachers who have used the material. Three schools indicated that they needed a data projector to fully optimise the use of the learning material.

Table 6: 2009 Questionnaire

Area	School	Completed questionnaire		Used material		Need a data projector
		Yes	No	Yes	No	
Somerset West and Stellenbosch districts	18	12	6	4	8	3

In 2010, a telephonic survey was conducted with 68 schools to determine the use as well as user-friendliness of the material, the grade to which it was presented, whether the teachers needed help and whether they had used the assignment (Flash drive Appendix 8). The results of this survey can be seen in Table 7 below.

Table 7: 2010 Telephonic Surveys

Area	Number of schools who used the materials			Grade	Need help		Booklet		Share the material		Showed the DVD		Assignment		Receive e-mails	
Western Cape	Yes	No	No * DP		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Total	**49**	**18**	**12 (2)**	**8-12**	**7**	**45**	**28**	**20**	**24**	**19**	**20**	**23**	**9 (9)**	**25**	**20**	**34**

*DP: Data Projector

Feedback from the teachers was very positive, they found the information very clear, to the point and very useful, especially the pictures that are included. Many teachers noted that the materials saved them a lot of time as they no longer need to have to source for information on the topic of renewable energy (Flash drive Appendix 9, L21-23).

4.3.3 Establishing school networks

The workshops went hand in hand with the development of networks. Therefore another aspect of the schools' programme was to establish relationships with the existing school networks so as to have a platform from which to implement the materials. In 2010 contact was made with the Head of Curriculum: Natural Science at the Western Cape Education Department (WCED) and connections were made with the Natural Science Curriculum Advisors (Flash drive Appendix 9, L26-27). Up to 2012 the materials was mainly implemented and disseminated in high schools in the Western Cape through the Natural Science Curriculum Advisors of the WCED. The reason for this was the limited number of resources I could print and therefore I could only implement in a limited number of schools.

Through the surveys and workshop evaluations, it was determined that teachers don't have easy access to data projectors (Flash drive Appendix 10, L18-20) and therefore a decision had to be made whether booklets or posters will be added in order to facilitate the presentation of the learning content. In a meeting with the national coordinators of the Wildlife and Environment Society of South Africa (WESSA) Eco-Schools programme in 2011, valuable feedback helped to determine that posters would be an easy, cheaper and better option. Through the connection with WESSA Eco-Schools the material was implemented in the Western Cape, Eastern Cape and Northern Cape, KwaZulu-Natal and the Free State, over the next few years. Implementation sessions were also conducted through the Cape Town Observatory- and Limpopo University Science Centres.

From a humble start at 3 schools, the learning material was disseminated to more schools and therefore more teachers and learners could receive the training and learning material.

4.3.4 Funding

An important part of the success of the schools' programme is the funding. At the end of 2008 a proposal was send to Eskom for funding for the programme, but unfortunately with no success. In 2011 another proposal was written and presented to a few businesses; the aim was to implement the materials throughout the country as 2012 was the United Nation's year of 'Sustainable Energy for All'. The proposal was presented to Eskom, Sasol, DST, Anglo Gold and DoE, unfortunately with no success once again.

The Centre allocated yearly a certain amount of money to the schools' programme, resulting in a certain number of sets of material that could be printed; the number of sets of material determined the number of schools that could be reached. From the start the material was provided for free to the teachers. Because of the use of so many images, we tried to have it printed in colour but that made it very expensive to reprint. Later on, the printed material was done mostly in black and white due the prohibitive cost of colour printing.

4.4 Phase 3: 2012 - 2014

The aim of Phase 3 was to update the material, develop posters, to establish networks in Natural Science through which the roll-out strategy could take place, and to source funding for the programme.

4.4.1 Material update

The field of renewable energy is a dynamic one and therefore it is important that the learning content must incorporate the newest findings in the industry. The original materials developed in 2008 was revised in 2012 in order to align the content with the latest developments in renewable energy as well as the National Natural Sciences CAPS of July 2011, specifically the Energy and Change Knowledge Strand for grade 9 learners which included a component on renewable energy (Flash drive Appendix 10, L9-13).

Results from surveys conducted in 2009 and 2010 indicated that teachers found the information comprehensive and ready to use. Once again, teachers specified that the material saved them valuable research and preparation time (Flash drive Appendix 10, L15-20). Survey results indicated that some schools were unable to use the PowerPoint presentations due to resource constraints (e.g. no projector available) and therefore a poster on each module was added. The posters were developed in such a way that if a teacher did not have access to a data projector, they could still use the manual and teach from the poster (Flash drive Appendix 11).

4.4.2 Workshops

The learning environment of the schools' programme was dynamic and the learning content of the material was changing. Implementation and workshop strategies had to adapt to these changes.

Due to the lack of funds, only one workshop was presented in 2012 with 40 teachers receiving the material. Furthermore the networks that had been established in 2011 could unfortunately not be followed up.

Table 8 shows the number of workshops that were presented and the number of schools, teachers and students who received the training over the time period from 2012-2014. (Flash drive Appendix 12):

Table 8: Summary of workshops presented from 2012-2014

Year	Number			
	Workshops	Schools	Teachers	Students
2012	2	30	65	
2013	9	115	133	
2014	12	277	376	25
Total	**22**	**422**	**574**	**25**

In April 2013 funds became available from the main sponsors of the CRSES and implementation was done differently to previous years. The workshop sessions became longer to give teachers an experience of the material, and feedback included questionnaires which were completed during the workshops and an email survey at the end the year (Flash drive Appendix 10, L87-92). The reason for the questionnaire and workshop evaluation after each session was to determine whether understanding of renewable energy and growth has taken place and the survey had to determine how many teachers used the material (Flash drive Appendix 2013).

Feedback received from three workshops held during July-August 2013 indicated that the 72 participants would use the material. On the question whether the participants gained a better understanding of the various topics being addressed in the different modules, the feedback indicated that more than 80% of the participants gained a better understanding of the various topics related to renewable energy (Flash drive Appendix 13, L86-90) .

From the information of the questionnaire it can be concluded that the participants gained more knowledge on the different types of renewable energy (Flash drive Appendix 13, L129-132) but unfortunately this wasn't verified against their existing knowledge.

At the end of the third term, September 2013, a survey was sent out to the 72 teachers to determine whether they have used the material. The survey contained only three questions, namely did they use the material, for which subject and which grade. The shortness of it was to increase the possibility that those who receive their emails on a mobile phone would respond. Only 8 (10%) responded to the survey of which 6 reported that they had used the material in the third term (Flash drive Appendix 14, L39).

In 2014 two different questionnaires were used in the workshop as well as the email survey at the end of 2014. The first questionnaire had space to comment and valuable feedback was gained from teachers through their comments (Flash drive Appendix 15, L36-49).

More than 370 teachers attended the workshops in 2014. The focus area was grade 9 Natural Science teachers but since the implementation process worked best by making use of the existing school networks of the Department of Education, WESSA Eco-schools and Science Centres, the participants attending the workshop were not necessarily only grade 9 Natural Science teachers. An interesting fact emerged from having participants from a variety of subjects, because all of them could see how the materials related to their various subjects, grades and capacities other than only grade 9 Natural Sciences (Flash drive Appendix 15, L57).

As the teacher's previous knowledge on the subject was not tested, a pre- and post-workshop test was added to the questionnaire. The results showed that the participants did gain knowledge during the workshop and therefore they are better equipped in educating learners on this subject Flash drive Appendix 16, L72-86).

Although the feedback indicated that the resources would mainly be used for grades 7 to 9, there was also an indication that resources can be used for grades 10 to 12 learners of different subjects such as Natural Science, Life Science, Physical Science and Geography (Flash drive Appendix 16, L118-119).

An Environmental Education Association of Southern Africa (EEASA) conference paper was written on the above-mentioned questionnaires from workshops being held from July 2013 to May 2014 as well as the 2013 email survey (Flash drive Appendix 17).

Table 9 gives a short summary on the data received from teachers on the email surveys sent out at the end of 2013 and 2014. The table shows the number of teachers who received the survey, the number of responses that indicated that 'yes/no' they are using it, as well as for which grade and in which subject the learning material will be used (Flash drive Appendix 14 & Appendix 18).

Table 9: Data received in email surveys in 2013 and 2014

Teacher survey	Total number of teachers who received the survey	Number of teachers who used the materials Yes/No	Grade	Subjects
2013	72	Yes: 8	Grade 7-9	Natural Science
2014	357	Yes: 60 No: 7	Grade 7-9 Grade 8-12	Natural Science Technology Life Sciences Geography Physical Science

4.4.3 Establishing of networks

The roll-out strategy of the learning material still carried on with the DBE and Science Centers. Another network was also established with Fundisa for Change, a national programme to enhance transformative environmental learning through teacher education. Regional *Trainers of Teachers* (TOT) were established and CRSES forms part of the Western Cape region (Flash drive Appendix 19, L12-19).

4.4.4 Funding

As indicated above, a big challenge still remained for funding for the schools' programme. Proposals were written for a number of companies and institutions (Flash drive Appendix 19, L38-45).

4.4.5 Remarks from 2014

Remarks from the 2014 schools' report highlighted that the necessity-of follow-up support is not only to support teachers with activities, assignments and assessments, but also to determine the effective use of the resource material in the classroom. As indicated above, using email for feedback provided only limited response so we realised that an alternative support and feedback strategy had to be developed. One possibility was to make use of mobile technology as it is a more available, inclusive and exciting tool of engagement from the learners' point of view and it can serve as a monitoring and evaluation (M&E) tool to determine whether the resource materials were used by the teachers (Flash drive Appendix 19, L34-37)

The success of the learning materials is not only **that** the material is used, but also **how** the material is used by the teachers. Gaining insight in this phenomenon is the reason why the researcher enrolled for a Master's degree in Environmental Education at Rhodes University for 2015-2016. The findings of this research will be used in not only the updating of the material but also to empower the teachers on the best way to present the material.

4.5 Phase 4: 2015 - 2016

The aim for 2015/16 was to reposition the schools' programme in terms of a roll-out strategy and the development of material-and activities on renewable energy in more than one subject (Flash drive Appendix 20, L18-25) and to determine how teachers are using the material.

4.5.1 Material

From a survey completed in 2014, it was evident that teachers of various subjects, namely Geography, Life Sciences, Technology and Physical Sciences, were using the material. Because of this, the aim now was to develop materials and activities that could be used in more than one subject.

In 2015 subject-specific learning materials were developed and added to the core materials:

- Mathematics for grade 8-9: focusing on global graphs and data handling
- Physical Science for grade 10-12: exploring solar panels, the efficiency of solar panels and generators, and to demonstrate mechanical power by using a wind turbine to do the work. This was done in collaboration with the Technology Research Activity Centre (TRAC) at Stellenbosch University.
- Geography for grade 10-12: the content, aligned with the CAPS curriculum, focused on data handling, map work and GIS (Flash drive Appendix 20, L81-93)

At the beginning of 2016, the learning materials on renewable energy were updated in line with the latest developments on renewable energy in South Africa. The update included information of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) (2.2.1) and images of these renewable facilities from locations all over the country. The assignments mentioned above, developed in four different subjects in 2015, were loaded on a flash drive to give all the teachers receiving the new materials in 2016 access to the new activities (Flash drive Appendix 21, L 22-28) (Flash drive Appendix 27).

This was the second update since the start of the schools' programme in 2008. The feedback received from the curriculum advisors and teachers shows that they found the resource comprehensive and an 'eye opener', because most of them were not aware of the recent developments in the renewable energy sector in South Africa.

4.5.2 Workshops

The workshops became longer and suggestions on how the material could be presented were shared with the teachers.

Table 10 shows the number of workshops that were presented, and the number of schools, teachers and students who received the training over the time period from 2015-2016 (Flash drive Appendix 22).

Table 10: Summary of workshops presented from 2015-2016

Year	Number			
	Workshops	Schools	Teachers	Students
2015	13	95	186	242
2016	10	88	146	20
Total	**23**	**183**	**332**	**262**

4.5.3 Establishing of networks

In collaboration with the Geography Curriculum Advisors of the Western Cape Department of Education, CRSES successfully presented the learning material in two Geography workshops in 2015 and 2016. The learning material was well received by the teachers and was extensively used in the grade 11 Geography curriculum (Flash drive Appendix 20, L28-35).

Fundisa for Change is a collaborative programme formed specifically to enhance transformative environmental learning through teacher education. It was established as a partnership programme involving many of South Africa's major environmental organisations, including the state, parastatal, NGO and private companies, which have an interest in environmental teacher education. Fundisa's core objective is to strengthen the teaching of environmental concepts in schools (Flash drive Appendix 20, L36-45, Appendix 21, L38-42).

In collaboration with the Schools Development Unit (SDU) of UCT, four Geography grade 10 -12 teachers were trained in the Fundisa for Change Climate Change courses and three Climate Change senior phase courses were presented in 2015 and 2016. The CRSES renewable energy learning material is a valuable addition to the Fundisa courses (Flash drive Appendix 20, L42-43 Appendix 21, L.43-46).

4.5.4 Funding

In 2015 external funding was secured for the first time. Two proposals written in 2014 lead to successful project implementation, namely (Flash drive Appendix 20, L46-80):

- The **Cape Higher Education Consortium (CHEC)** requested the implementation of the learning support material to students (pre-service teachers) of the Faculty of Education at SU who are studying a Post Graduate Certificate in Education, with curriculum studies in Geography (Flash drive Appendix 24).
- **Economic Development Solutions (EDS)** requested that the Centre provided professional development training on renewable energy to teachers in the Sishen area. The project included developing activities in Mathematics, Physical Science and Geography that were suitable for incorporation in the CAPS curriculum. A three day course was presented to teachers in Sishen in the Northern Cape together with Fundisa for Change and TRAC (TRAC South Africa is a national, non-profit Physical Science intervention program of Stellenbosch University. The objective is to support and uplift science, applied mathematics and technology education in South African secondary schools) (Flash drive Appendix 23).

In 2016 external funding was again secured through the implementation of two projects for Economic Development Solutions (EDS). They requested that the Centre provided Teacher Professional Development and training on renewable energy to teachers in the Gouda and again in the Sishen area. Gouda was a one day course and Sishen was a three day course presented in collaboration with Fundisa for Change and TRAC (Flash drive Appendix 21, L53-80).

- **Economic Development Solutions (EDS): Sishen Solar Facility**
  CRSES had a follow-up in 2016 on the course which was presented in 2015 with EDS in the Gamagara district, in the Northern Cape. This year we also visited the Sishen Solar Facility (Flash drive Appendix 25).
- **Economic Development Solutions (EDS): Gouda Wind farm**
  A Teacher Professional Development course was presented in renewable energy for teachers in the Gouda area. The aim of the course was to empower teachers to utilize curriculum opportunities in renewable energy by using the CRSES renewable energy materials. Twenty seven teachers attended the session and we also visited the Gouda Wind farm (Flash drive Appendix 26).

4.5.5 The Renewable Energy Schools' Programme as a context for a Master's research

Against the background of this review on how a responsible programme on renewable energy was not only developed but also implemented during a period of nine years, the rationale for this research is to deepen our knowledge on how teachers are using the materials, to assess how the

use of the materials appears to be supporting learning and document the value that is added to their teaching and learning practises.

The results to the review (Chapter 4) and the assessment of use and learning (Chapter 5) will be used to not only update the material, but also to inform and improve the teacher professional development through workshops.

4.6 Conclusion

Table 11 provides a summary on the development of the Renewable Energy Schools' Programme. The coloured columns indicate the years.

Table 11: Summary on the Renewable Energy Schools' Programme

		Phase 1		Phase 2		Phase 3			Phase 4	
Materials		Develop materials: DVD, PowerPoints, Teacher's manual					Update materials add 8 posters			Update materials add assignments
			Add glosssary	Material on CRSES website						
Networks		Pilot project in 3 primary schools		DBE (Natural Science)			DBE, Eco Schools, Science Centres		DBE (Geography), Fundisa for Change	
				Eco Schools						
Workshops	Subjects	Natural Science		Natural Science, Technology		Natural Science	Natural Science, Life Science, Geogrpahy, Technoogy		Focus on Geography & Natural Science	
	Schools	3	18	119	72	30	115	277	95	88
	Teachers	3	27	117	110	40	133	376	186	146
Funding									Sishen and CHEC	
										Sishen and Gouda
		2008	2009	2010	2011	2012	2013	2014	2015	2016

Chapter 5 Data Presentation on Cases of Use to Support Learning

5.1 Introduction

The evidence of the unfolding project was presented in Chapter 4 and since the project inception, a lot of the evidence has already been reported on while the materials and the programme were developed. For this study, my primary objective is to look in detail at case evidence and try to get to a deeper understanding of how the materials are being used in the learning actions within classroom settings.

This Chapter presents an analysis of the feedback received from teachers on how the learning material has been used to support learning in differing curriculum subjects. Following the survey and interviews, in-depth feedback was solicited from seven teachers of which five are presented as in-depth case reviews. The case studies of patterns of material use in curriculum settings focused on:

- what materials had been used,
- how they had been used in lesson sequences and
- what happened in the teaching and learning interactions reported.

The data were read using the Anne Edwards learning task sequence framework as a lens to identify patterns of use to initiate and support learning. This provided insights into possible effectiveness of learning as an ESD process as well as the value being generated for and by the teachers.

5.2 Questionnaire

As part of the data collection, the teachers completed a questionnaire which gives the contextual background of each case as well as on how and what had been used. The questionnaire was answered by Cases A, B, C, D, E, F and G and determined what components and topics of the materials had been used, to which grade the material was presented and whether the materials generated the necessary value to meet their learning needs. Questions One and Two of the questionnaire were incorporated as background information in the five in-depth cases examined. A summary of the questionnaire data is presented below. (Full feedback on questionnaire can be viewed in Appendix F).

5.2.1 Identifying the material that had been used

The questionnaire indicated that the learning material was used in the following curriculum areas: Geography grade 11, Life Sciences grade 10, 11 & 12, Natural Science grade 8 & 9 and Mathematics grade 8.

- Case A included the material in 'Life on Earth' in grade 10 Life Sciences (CAI, L3-7) and in Human Impact in Life Science grade 11 & 12, as well as in the Energy and Change knowledge strand in grade 8 & 9 Natural Science (CAAL, L14-15, CAQ, L48, 91).
- Case B incorporated the material through the Geography Questioning method, under research for grade 11 (CBQ, L76; CBAL, L9-14),
- Case C included the material in the Mathematics curriculum where it fitted with the content area of measurement and data handling (CCLP, L3-4).
- Case D used the material for grade 9 Natural Science under the Energy and Change knowledge strand (CDLW 6, 5, 4, 3, 2, 1).
- Case E included the material in Natural Science grade 8 & 9, also in the Energy and Change knowledge strand (CEAL, L8)

The conceptual linkages in all of the above cases were climate change and the associated increase in the greenhouse effect as a result of human impact on the environment. All the topics, which included Energy, Electricity, Solar-, Wind- Hydro-, Biomass-, Geothermal and Ocean Energy and Energy Efficiency, were used (Q4, L96), but varied for the different cases, depending on the applicability for the different subject areas. It appears that the main reason why certain topics in the learning material were chosen was the links with CAPS (CAQ, L94), (CBQ, L80-83), (CDQ, L34-36), (CEQ, L74-79), (CGQ, L71-72).

In the questionnaire, the question about the use of the energy assignment was intended to determine the curriculum use of the energy audit included in the. Some cases designed their own assignments and reported on these, but Cases A, B and E made use of the energy audit. Case A reported that they used it as a Continuous Assessment (CASS) activity (CAAL, L6-8). Case B reported that only some of the learners completed the assignment, but their feedback gave momentum to the rest of the project work (CBAL, L26, 29-30).

Case E added two additional research questions and used it as a summative assessment task (CELW2, L19-46).

The majority of the learners responded positively to the DVD: 'Planet Earth, a Living Heritage'. All cases reported that it was valuable to watch because of the "high quality" (CBQ, L67-68), noting

how "it broadened [the learners] horizons" (CCQ, L67), had "good visuals [and] interesting facts [and it was] relevant" (CFQ, L62-65). Case E mentioned that "it was inspiring and valuable, [but] unfortunately it did not accommodate deaf learners by having subtitles" (CEQ, L67-68).

From the feedback to Question 7 (Q7, Table 5.5) it is clear that the manual, DVD and flash drive met the teachers' needs in terms of the following criteria: all cases reported that the manual, DVD and flash drive were clear and easy to follow, noting that the content is in a logical sequence, it covers the most important aspects of the subject, and the learner material meets CAPS requirements. It was also reported that the teaching material had been compiled in such a way that it provided for the differing abilities of learners (Q7, Table 5.5,), but two cases mentioned that it does not provide for slow learners (Q7, table5.5).

Case A mentioned that more information is needed on the enhanced Greenhouse Effect and depletion of the ozone layer and research questions should be added to the end of each topic (CAQ, L107-108). Case E and G reported that the content is too comprehensive for grade 9 Natural Science especially in light of the time allocated to renewable energy in CAPS (CEQ, L91-97), (CGQ, L80-81). Case B reported that he gave the materials to another teacher who did not attend the training workshop, but this teacher struggled to use it (CBQ, L 97-98).

All the cases except Cases A and B indicated that the workshop was the first training they had received on renewable energy. Most respondents indicated that the training was sufficient but Case C mentioned that guidance on how to incorporate it with Mathematics would be appreciated (Q7, L153).

5.3 Using the learning task sequence to determine how the materials are used

Each case was reviewed in terms of how the materials were used to support learning. The Anne Edwards task sequence framework provided me with a way of identifying teaching and learning processes and tracking how these developed in learning sequences. The data were derived through a careful reading in the lesson descriptions as educational patterns of use. Reading the developing learning activities and learners' work it was possible to get a sense of the developing teaching and learning processes as these had been formed around the materials used.

5.3.1 Case A

In Case A the materials were used by the teacher for two different groups of learners: grade 8 & 9 Natural Science and grade 10, 11 & 12 Life Sciences. The data received from Case A can be viewed in Appendix G. In Table 12, the background information on Case A is given.

Table 12: Background information on Case A

Background information on Case A	
Province: Eastern Cape	**Course Attended:** 2014
Subject: Natural Science **Grade:** 8 & 9	**Subject:** Life Sciences **Grade:** 10, 11 & 12
CAPS: Grade 9 - Natural Science: Energy and Change Grade 11 – Life Science: Human Impact and Respiration	
Data Provided: Questionnaire, Interview, Account of Lessons taught, Learners work (Appendix B)	
Materials used: Posters, PowerPoint presentations, Assignment on energy use, Teacher manual, Glossary	
Learner Assessment: Assignment on Energy used as CASS activity	

Description on how the learning materials were used, derived from the teacher's account of the lessons.

The teacher mentioned as context that her school is "an Eco-School in its fith year and will be attaining an International Flag at the end of 2016. One of the themes which [they] have to work on every year is 'Resource Use'". She also added that "every year [they] enter research projects into the Eskom Expo for Young Scientists. Last year one of [their] learners represented South Africa at the Intel International Science and Engineering Fair with his research project on applying worm tea to crops in developing communities to increase food security and alleviate poverty. Renewable energy is a very good field which the learners can base their research on and [they] would like to promote this at [their] school" (CAQ, L 28-36).

The materials were presented to grade 8 & 9 Natural Science learners (CAAL, L10). In the lesson account, the teacher mentioned that they had the "posters laminated…. after…..the course in 2014 (CAAL, L3-4). The posters were displayed in two passageways at the school where learners and sometimes even parents appreciate them" (CAAL, L4-5). **Quadrant 1, knowledge is displayed by the teacher by making use of the posters as mediation tool to provide an overall orientation.**

The teacher indicated that they made use of all the available components of the materials for Natural Science Grade 8 & 9 and for Life Science Grade 10-12. Except for the printed booklet, the teacher used "the DVD, PowerPoint presentations, teacher's manual, posters and glossary" (CAQ, L48, 91). The PowerPoint presentations were "used to explain the differences between renewable and non-renewable energy as well as the greenhouse effect" (CAAL, L9-10). **Quadrant 1,**

introduction to new concepts, by making use of the PowerPoint presentations as mediation tool.

She mentioned that value was added to the curriculum because "textbooks are not comprehensive enough and to teach the section well, one does need extra information and the given resources supplied that" (CAQ, L50-52).
The teacher mentioned that they used the "practical assignment on slide 12 of the Electricity section with [their] grade 9 Natural Science learners (Physical Sciences section)" (CAQ, L63, CAAL, L6-7) and that the learners fared "good" in the assignment (CAQ, L63). **Quadrant 2 - tightly structured activity, where learners engage with new concepts**. She added that "this is a lovely CASS (Continuous Assessment) activity. In this case a cost analysis was added in an extra column to the table" (CAAL, L7-8). **Quadrant 3/4 - teacher mediated enquiry into local context.**

Unfortunately she could not find the DVD: 'Planet Earth, a Living Heritage' and therefore the learners did not watch it. She added that "learners are very attentive when watching videos. One could make an assessment activity out of it, by asking questions regarding the video after they have watched it to reinforce the knowledge and to test their listening skills" (CAQ, L80-82). **Quadrant 2 – learners need to internalise new concepts and reflect on it.**

On the question why she made use of all the topics in the learning material she reponded that "all these topics come up in the Natural Sciences and the Life Sciences syllabi"(CAQ, L94)
She mentioned that the grade 9 learners did a research project on "Renewable energy sources" in the third term (CALW, L1-6). In her feedback on the research project, she reported that she was "disappointed on how the learners did the project, most of them were either helped by their parents or they copied and pasted the information from the internet. Also they did not find good information on how much renewable energy has already been built in South Africa. It seems that they have also struggled to find information on what is available" (CAI2, L6-10).

She suggested a different strategy to do research, namely "to focus on Hypothesis Testing / Scientific Research—where the child goes out and asks questions and does interviews or sends out emails to determine the results" (CAI2, L12-15).

Furthermore the teacher plans to "motivate [the learners] to look at renewable energy as a topic for 2016 Eskom Science Expo" (CAAL, L22-23). **Quadrant 3 – learners engage with a more open task and have to show learner agency**

Table 13 presents a summary of the material used and the teaching strategy, plotted in the four quadrants of the Edwards learning task sequence.

Table 13: Case A summary on materials used for grade 9 Natural Science

Quadrant 4 Assessment of learning achieved	**Quadrant 1 Introducing and framing knowledge**
Teacher added a column on cost analysis for the energy audit on slide 12 and used it as a CASS activity (CAAL, L7).	The posters were laminated and put up in two passageways of the school (CAAL, 15). All the PowerPoint presentations were used to explain the differences between renewable and non–renewable energy, the enhancement of the greenhouse effect as well as the different types of renewable energy technologies (CAAL, L9, CAQ, L91).
Quadrant 3 Enquiry and independent studies	**Quadrant 2 Learning activities to clarify concepts**
The teacher motivated learners to use renewable energy as topic for their Eskom Science EXPO (CAAL, L21 –L23). Grade 9 learners did a research project on "Renewable energy sources" in the third term (CALW, L1-6)	The energy audit assignment was used with the learners (CAAL, L6).

Case A Life Sciences, grade 11 and 12

The teacher stated that "the differences between renewable and non-renewable ….and ….the enhanced greenhouse effect is taught in grade 11 and 12 Life Sciences" (CAAL, L14-15). She added that they "also made use of [the] slides on dams in the Hydro Energy section when [she] dealt with *Human Impact* and how the construction of dams impact on the freshwater resources". She commented that the "resources [are] very useful for educators when teaching Human Impact in grade 11 Life Sciences (the course is repeated in grade 12)". In addition to this she added that "Biomass is also covered in this section [of Human Impact] as well as in the chapter on respiration in grade 11 Life Sciences" (CAAL, L12-16). The learners "enjoyed the section on biomass energy" (CAAL, L17), because the school is linked to a rural school "Chintsa East who makes use of biofuel to cook their lunch" (CAAL, L17-18), this is described as "an inspiration for [the learners]" CAAL, L18). **Quadrant 1 – teacher displays knowledge and introduces key concepts**

She added that aspects which the learning material did not take into consideration and needed was "more detailed explanations [of the] Enhanced Greenhouse effect and Ozone" (CAQ, L107). She suggested that "it would be good if suggestions for research topics are given after each

section" (CAQ, L108). **Quadrant 3 – learners enage with more open tasks and take responsibility for their own learning.**

She also added that "the grade 11 learners who are interested in studying Engineering really enjoyed [the] inspiring DVD on [the Centre's] website" (CAAL, 19-20, CAQ 108-111). **Quadrant 1 - – learners are introduced to further study possibilities**

She asked whether the researcher can supply her with research ideas on renewable energy (CAAL, L29, CAQ, L 111). In line with doing research at the school, the teacher mentioned that they appointed a new teacher in Life Sciences, who did his postgraduate diploma in sustainable development and she was "looking forward to his input in motivating research at school" (CAAL, L24-25). She also said that "one of [their] matrics … won a gold medal at the Eskom International Science Fair [in 2015]…… and he represented SA at the Intel International Science Fair in Pennsylvania, USA" (CAAL, 26-28, CAQ, L31-34). **Quadrant 3 – showed learner independent inquiry and agency**

In Table 14 a short summary is given on how the teaching strategy was plotted in the four quadrants of the Edwards learning task sequence.

Table 14: Case A summary on materials used for grade 11 & 12 Life Science

Quadrant 4	**Quadrant 1**
	Differences between renewable and non–renewable energy as well as the increase in the greenhouse effect which is taught in Life Science grade 11 & 12 (CAAL, 11). Use information on Hydro and Biomass energy in section of Human Impact in LS grade 11 & 12 (CAAL, 12-18) Enquiry into use of bio-energy in a school in Chintza (CAAL, L17)
Quadrant 3	**Quadrant 2**
Teacher asked for research ideas in renewable energy (CAAL, L29).	

In an interview the teacher suggested that the learning material could be used for Life Sciences grade 10 when [they] cover "Life on Earth" in the grade 10 Life Sciences curriculum. [They] teach the causes of the five past mass extinctions in detail and then discuss the sixth one caused by mankind. The question is then asked, what can [one] do to prevent this speedy sixth extinction? The use of renewable energy can then be used as one of the solutions" (CAI, L3-7).

The teacher also suggested that "subject advisors should be made aware of the material; this will ensure integration with the curriculum" (CAQ, L125-126)

Summary: Learning that has been supported by the learning material in Case A

The introduction of new concepts and meaning-making took place through the use of the posters in the passageway and the use of the different PowerPoint presentations for grade 8 & 9 and grade 11 & 12. Children passed the posters daily and the concepts of what is already known were enhanced and revisited. Learning supported through the use of the material was that learners could engage with the renewable energy learning material through the slides and posters and make connections to the biofuel project in Chintza.

Through the use of the energy audit the teacher not only formatively assessed the Q1 instruction but began to mediate the connections between what was already known and new concepts that they were encountering. By adding another column to the activity and using it as a CASS activity, the formative assignment of Q2 became an activity for summative assessment and therefore supported Q2 and Q4. The teacher mediated Q3 enquiry work through the use of an open task, but with dissatisfying results. Learners 'copied and pasted' from the internet or parents helped to do the assignment. The teacher expressed a need for more open tasks which would enable learners to apply key concepts and do independent research. She added this would strengthen learner-led enquiry Q3 and strengthen curriculum learning as a process of ESD.

Evidence of value added for the teacher in the use of the learning material

The learning material is more comprehensive than the existing textbooks and therefore adds value to teaching the topic. The use of the posters added value to learners and even parents' understanding of renewable energy. By adding another column to the energy assignment the teacher could use it as a CASS activity. The learners enjoyed the biomass section because of the link with the rural school Chintsa East which is making use of biofuel to cook lunch. Value was added for grade 11 learners who are interested in studying Engineering by watching the inspiring DVD on CRSES's website.

5.3.2 Case B

In Case B the materials were used by the teacher for two groups of grade 11 Geography learners. The data received from Case B is referenced as Appendix H. In Table 15 is given.

Table 15: Background information on Case B

Background information on Case B			
Province: Western Cape	**School size:** ± 600	**Socio Economic Context:** Middle to high income	
Profile: Boys & Girls	**Equipment available:** Data projector, Laptop, Whiteboard		
Subject: Geography	**Grade:** 11	**Class size:** 25	**Timeframe:** 2 weeks
Medium of language: Afrikaans		**Resourced school/Under-resourced school:** Resourced school, computer centre	
CAPS: Geography grade 11, second term curriculum, under Research			
Data Provided: Questionnaire, Account of lessons and Learner's work (Appendix C)			**Course Attended:** 2016
Materials used: Watched DVD; Printed booklet for learners; PowerPoint presentations; Employed teacher's manual; Posters; Glossary; Geography assignments; Energy audit			
Learner Assessment: Cape Recife Windfarm and Koeberg			

Description on how the learning materials were used derived from the questionnaire, the teacher's account of lesson and a sample of learner's work.

The materials were presented in "two Geography grade 11 classes; [the teacher] covered some topics of the materials over a timeframe of two weeks" (CBAL, L3-4), "it fitted in the syllabus under Research. The rest will be covered later in the year, under Resources and Energy" (CBAL, L5-7). The teacher mentioned that he "presented the material according to the Geographical questioning method[1] which is:

- What is it? Definitions, Concepts.
- How does it work?
- Where does it occur?
- How does it influence people?

[1] The Geographical questioning method is explained in the Geography CAPS document page 10.

- What can we do about it?" (CBQ, L76; CBAL, L9-14). (Geography Grade 10-12 CAPS, 2015)

Quadrant 1- Teacher mediated

The following topics were covered during the two weeks: "The greenhouse effect, climate change, renewable energy, non-renewable energy, generation of electricity, and wind energy" (CBAL, L20-25). The reason why the teacher introduced and discussed only the key concepts in these topics was because of the "time available, [he] will do the rest later. [He also chose] wind energy, because [they] had [a] sports meeting in Vredenburg so [they] passed a wind farm. [He] also did [the] assignment on Koeberg because of [the] Thys Point Nuclear plans being in the news. This material fitted into the syllabus well under the topic of research" (CBQ, L80-83). **Quadrant 2/3 – mediated local enquiry with learner initiative in mapping solutions.**

The teacher used "all the available components of the materials in the six topics" (CBQ, L33). "An overall orientation was displayed [by the teacher] through the use of all the different components– DVD, PowerPoint presentations, printed booklet, posters and glossary (CBAL, L16-18).He added that "for the sake of time and to focus on the role of humans, it was not expected of learners to do research on each concept, therefore the focus was to provide the key concepts so that they could become known concepts in discussions and investigations which would follow later on" (CBAL, L20-22). **Quadrant 1 – key concepts presented by making use of the PowerPoint presentations, posters, glossary and printed booklet as mediation tool.**

The teacher commented that the value added by using the material was "it is a South African product with local pictures and examples. It gave us hope and made us proud" (CBQ, L39-40).

The teacher used the "PowerPoint presentations and video materials to answer the first two questions of the Geography questioning method" (CBAL, L16-18). [What is it? Definitions and Concepts, and How does it work?]. It appeared that the purpose of doing it like this was to give learners "background information and an introduction to key concepts so that they would be able to handle the content meaningful (CBAL, L16-18), and take part in discussions and investigations later on. Some concepts were presented by the teacher and some by learners" (CBAL, L20-25). **Quadrant 1 – introduction to key concepts**

The teachers indicated that all the learners responded "positively" to the DVD: 'Planet Earth, a living Heritage' (CBQ, L 63). **Quadrant 1** He also mentioned that watching the DVD was valuable, because it is of a "very high quality, with very recent statistics and a lot of seen and unseen South African places. The learners are used to visual stimulation and this helped a lot" (CBQ, L 67-68).

The teacher went on to say that "the second Geography questioning method [How does it work?] attracted more attention, especially from the Physical Science learners (CBAL, L31-33). Physical Science learners explained to the other learners, with the help of a generator from the Science lab, how electricity is generated" (CBAL, L31-33). **Quadrant 1, key concepts explained by the more adult learner**

In terms of the energy assignment he mentioned that only "some learners completed the assignment on energy consumption"; he also added that it "was completed on an average level. A lot of hostel learners did not really take part and had easy excuses. It was more of a motivational problem than a real material problem" (CBQ, L49-54) (CBAL, L27-28). However "some learners did the assignment and the feedback had very positive results and gave the project momentum" **(**CBAL, L26, 29-30). He found that the value of the enquiry resulted in "an eye opener for a lot of them" (CBQ, L55). **Quadrant 2 – students show thinking skills and engage with key concepts through energy audit task.**

Unfortunately "not enough time was spent on maps; [the teacher] will emphasize it next time more because it is such an integral part of Geography. The question on where does it occur were a little bit neglected. Enough maps are included in the material, but [he] did not ask enough questions" (CBAL, L34-37). **Quadrant 2 & 3 - map work, learners engage with concepts, learning mediated mastery though the use of questions.**

The teacher continued by stating that "most of the group activity and research was done on the last two questions [How does it influence people? And what can we do about it?] The question about people involvement was well addressed in these activities" (CBAL, L38-40). The teacher did "two research questions provided in the material, the one was on the development of a wind farm close to Port Elizabeth and the other was on the Koeberg Nuclear power station" (CBLW 1, 2, 3, 4, 5). He mentioned that the learners engaged with concepts through the assignments which "are written in a way that learner involvement and group work was implemented very well" (CBQ, L37-38). **Quadrant 2/3 – learners engage with new found knowledge as well as showing thinking skills.** He also mentioned that "one of the biggest challenges for teachers is to be e-relevant in the classroom. This involves more than substituting paperwork with tablets, but the integration of soft- and hardware" (CBAL, L40-42). The value in this case was that "the activity was a [good] experience in e-learning and a big step forward. The group activity worked better than previously, maybe because of the diversity. A wide variety of skills was addressed in the activity and usually

only a few learners take part and the rest are apathetic, which was not the case with these activities. A number of learners used technology as a natural way of learning and the positive South African examples of solutions were a very nice experience in the class" (CBAL, L41-48).

The teacher's feedback to the learners' on their work included the following:

Learner One: "the report addressed pros and cons [of developing a Wind farm] and you [the learner] were able to take a stand" (CBLW1) **Q3**. Learner Two: "good way of putting your thoughts together, but what does a report look like, can you hand this in as a proposal for yes/no [to develop a Wind farm]" (CBLW2)? Learner Three: A "traffic jam will occur if all try to use the same [escape] route" [when an earth quake occurs close to Koeberg nuclear power plant] (CBLW 3).
Quadrant 2/3 & 4 – summative assessment, because learners were graded on their assignments

The teacher added the following valuable information on the RE material which was not covered in the questionnaire: "Schools are supposed to prepare learners to become independent members of the community that can play an uplifting role". Therefore the "positive attitude of the material [is] very valuable". He identified three action objectives in the materials that can be implemented:

- "Ways to integrate [the material] with an e-learning strategy,
- [a] very wide range of potential job opportunities [were] identified in [the] material, and
- what is my role that I can play as learner?" (CBQ, L111-115).

In Table 16 a short summary is given on how the teaching strategy was plotted in the four quadrants of the Edwards learning task sequence.

Table 16: Case B summary on materials used for grade 11 Geography

Quadrant 4 Assessment of learning achieved	**Quadrant 1 Introducing and framing knowledge**
As part of the two questions - How does it influence people? and What can we do about it?. This led to the completion of two research activities: the development of a wind farm close to Port Elizabeth and about Koeberg nuclear power station. (CBLW1, CBLW2, CBLW3)	Key concepts were introduced by the teacher on the greenhouse effect, climate change, renewable and non-renewable energy, electricity generation and wind energy (CBAL, L20-25), by making use of the DVD, PowerPoint presentations, posters, printed booklet, teacher's manual and the glossary (CBQ, L33).
Quadrant 3 Enquiry and independent studies	**Quadrant 2 Learning activities to clarify concepts**
"The question about people involvement was well addressed in the activities" of the wind farm development and Koeberg nuclear power plant (CBAL, L38-40). Learners engaged with meaning of the concepts through the assignments which "are written in such a way that learner involvement and group work was implemented very well" (CBQ, L37-38).	"The assignment on energy consumption was completed on an average level (CBQ, L49-54) (CBAL, L27-28) and some map work was done, although not enough (CBAL, L34-37).

Summary: Learning that has been supported by the learning material use in Case B

From the above it is clear that the material lends itself to the Geography-mediated questioning method to scaffold task sequencing from mediated introductory inquiry to solution-orientated narratives (Q1-4). The teacher indicated that he introduced the learners to the key concepts by using the PowerPoint presentations and video materials to answer the first two questions of the Geography questioning method [What is it? Definitions and Concepts and How does it work?], this supported Q1. It appeared that the purpose of doing it like this was to give learners background information and an introduction to key concepts so that they would be able to handle the content meaningful (CBAL, L16-18), and take part in discussions and investigations later on, which supported Q2 activities with some mediated independent group enquiry (Q 3).

The fact that some concepts were presented by the teacher and some by learners indicated the potential level of development for learners with the assistance from an adult or more capable peer.

By making use of the assignments, Koeberg and Cape Recife Wind farm, the group activity and research were done on the last two questions of the Geography questioning method, [How does it influence people? And what can we do about it?]. This supported Q2 activities to clarify concepts

and Q3 enquiries in the sense that learners engaged with concepts in Q2 but the assignment was scaffolded in such a way that it also supported independent inquiry which supported agency in Q3. Learner involvement and group work was implemented very well. The teacher also used the results of the two assignments as summative assessment in Q4.

The feedback the teacher gave on the learner assignments showed that learners were able to take agency and the teacher could, by using the assignments as summative assessment, give grades for new found understandings. The teacher's feedback also showed a jumping point for a new cycle of the learning task sequence to start.

Value added for the teacher in the use of the learning materials:

The use of the learning material according to the Geography questioning method added value to the teacher's strategy of teaching as well as to the material, because the questioning method opened up the possibility of using it in all four quadrants.

The fact that it is a South African product with local pictures and examples, added value for the learners and it made them proud and gave them hope. The same counted for watching the DVD, 'Planet Earth, a living Heritage', it was found valuable, because it is of a very high quality, with very recent statistics and a lot of seen and unseen South African places, and being a visual stimulation, learners enjoy it more.

The learning assignments stimulated learner involvement and group work, better than other times. E-learning was implemented very well. A wide variety of skills was addressed in the activities, because usually only a few learners take part and the rest are apathetic, which was not the case with these activities. A number of learners used technology as a natural way of learning and the positive South African examples of solutions were a very nice experience in the class.

As part of the Geography curriculum learners must identify job opportunities and ask questions like 'what can I do'? Both of these questions were addressed in the material, thus making it a very positive experience for learners.

5.3.3 Case C

In Case C the materials were used by the teacher for grade 8 Mathematics learners. The data received from Case C is referenced as Appendix I. In Table 17: Background information on Case C is given.

Table 17: Background information on Case C

<table>
<tr><th colspan="4">Background information on Case C</th></tr>
<tr><td>Province:
Northern Cape</td><td>School size:
778</td><td colspan="2">Socio Economic Context:
Low income, very poor</td></tr>
<tr><td>Profile:
Boys & Girls</td><td colspan="3">Equipment available:
Data projector, no whiteboard</td></tr>
<tr><td>Subject:
Mathematics</td><td>Grade:
8</td><td>Class size:
50</td><td>Timeframe:
6 days</td></tr>
<tr><td colspan="2">Medium of language:
Afrikaans & English</td><td colspan="2">Resourced/Under-resourced school:
Under-resourced school</td></tr>
<tr><td colspan="4">CAPS:
Natural Science grade 9: Energy and Change knowledge strand</td></tr>
<tr><td colspan="3">Data Provided:
Questionnaire, Account of Lessons, Interviews (Appendix D)</td><td>Course Attended:
2015</td></tr>
<tr><td colspan="4">Materials used:
Watched DVD; Employed teacher's manual; posters; glossary</td></tr>
<tr><td colspan="4">Learner Assessment:
Assessment on solar energy, Mathematical activities</td></tr>
</table>

Description on how the learning materials were used derived from the questionnaire, the teacher's lesson plan, a sample of learner's work, and follow-up interviews

As part of the context of the school, the teacher added that the feeder area of the school has a "high rate of unemployment" (CCQ, L 27) and that the community is "very poor" (CCQ, L22).

The materials were reported to have been used for Mathematics grade 8 learners. "The investigation has been done in the weeks before the June exams". The teacher noted that some of the "learners didn't take it seriously, because [the materials were used to support] a research project that was not to be reflected in their report marks" (CCAL, L2-4).

In the detailed lesson plan that the teacher provided, he indicated that the materials were used under the topic of Climate Change and that the theme was Solar Energy" (CCLP, L1-2). The reason for focussing on solar energy was because, "[they] have two solar farms just outside town" (CCQ, L78).

The teacher also indicated that the content area was "measurement; data handling; amounts, operations and concepts" (CCLP, L3-4).

The specified aim of the lesson was that "learners should be able to understand and grasp the following: renewable and sustainable energy sources, solar water heating, solar thermal power stations [and] specifically what solar energy is" (CCLP, L4-10) **Quadrant 1 – introduction to new concepts by making use of PowerPoint presentations and posters as mediation tools.**

The "learners will also complete activities on solar energy" (CCLP, L 11) and then "[they] will go on an educational visit to the Sishen Solar Plant outside Dibeng" (CCLP, L12-13) **Quadrant 1 – learners engage with new knowledge and are exposed to new concepts**. The teacher planned to use the following resources: The "Introduction to renewable energy sources- manual; Sishen Solar Plant; writing board; computer and projector; [the] activities [and] assignments, [and the] poster on solar energy" (CCLP, 14-19). **Quadrant 1/2 – introduce new concepts and engagement with new knowledge through the activities.**

The teacher noted that in terms of "existing knowledge, it was expected that learners have a decent knowledge of electricity as well as the drawing of graphs" (CCLP, L20-21).

In Lesson 1 the teacher used the following components of the materials: [the] "poster on solar energy, teacher's manual, the glossary, Maths energy assignments, and the DVD: Planet Earth, a Living Heritage (CCQ, L36) [to] discuss the following concepts with the learners:

- What is Energy?
- Renewable and non-renewable energy sources
- The world's energy resources
- Greenhouse effect
- Environmental impact
- SA energy use" (CCLP, L24-33)

He then added that "it would be expected of learners to take part in the discussions. [The teacher planned to] guide [the] learners with questions like: Can energy be created? Can energy be stored for later use? What do we need energy for? Give examples of renewable and non-renewable energy sources. How does it influence our environment? How does it influence you and your household" (CCLP, L34-38)? **Quadrant 1 – introduction of new concepts through questioning**
In the questionnaire the teacher indicated that "the majority of the learners responded positively and some negatively to the DVD (CCQ, L62). He further commented that watching the DVD added value by "broadening their horizons" (CCQ, L67). **Quadrant – 1 – Knowledge is displayed by the teacher to introduce key concepts**

In Lesson 2 the teacher planned to "explain to learners what solar energy is" (CCLP, L40-42), [by] using the PowerPoint presentation on solar energy slides 2 -18 (CCLP, L43-58). He planned to have the colour printed "slides put up on the board in sequence" (CCLP, L59-60) (CCQ, L74). He ended up by showing the slides on his laptop (CCI2, L41). According to the teacher by making use of the PowerPoint slides on solar energy value added to "the learners' understanding of solar energy" (CCQ, L42). **Quadrant 1**

The teacher planned for "learners [to] visit the Sishen Solar Plant" (CCLP, L62-64), before lesson three. The idea was that the "learners would be introduced to photovoltaic panels, how a solar farm operates and what the aim [oogmerke] of a solar plant is" (CCLP, L63-64). **Quadrant 1**

Unfortunately "[they] couldn't visit the solar farm" (CCAL, L 7-8)

In "lesson 3, after the visit [to the Sishen Solar Plant he planned for] the learners to complete the following activities:

- Activity 1: Matching descriptions to graphs – group work
- Activity 2: Interpreting graphs – individual work
- Activity 3: Showing increase and decrease on graphs – individual" (CCLP, L67-69). **Quadrant 2 – learners engage with activities to clarify key concepts.**

In an electronic interview he mentioned that he had made use of the above mentioned activities (CCI, L19). He planned that after the above mentioned lesson "consolidation, summary and homework" would follow (CCLP, L70). "Lesson 4 was used for assessment (CCLP, L71), and the learners completed the following (CCLP, 77-93) assessment" (CCLP, L72), which is not part of the materials but a formative assessment task he designed. **Quadrant 2 – learners show skills acquired**. In the lesson account, the teacher mentioned that "most of the enquiry assignments were not completed" (CCAL, L5). He "summarized the learner's work" on assessment 4 (CCLW, L13) as follows:

To answer Question 1 they had to "write a paragraph of about 40 words on [their] opinion of solar energy" (CCLP, L80)? The teacher "summarized the learner's work" (CCLW, L13) as follows:

- "The sun gives us energy
- The sun gives us energy to generate electricity
- The government must provide us with solar panels so that we can save electricity
- Solar energy is expensive to install
- Deben has enough solar energy to generate electricity from the sun" (CCLW, L14-18)

In Question 2 the learners had to "name five things which [one] can do to make more use of solar energy" (CCLP, L 81)?

Most learners wrote the following:

- "I can make a sun stove.
- I can put drinking water in the window to get a bit warmer. I can then drink the water to become a little bit warmer.
- I can build in big windows in my house to heat up the room during winter.
- I can build a window in the roof to save electricity, the sun will shine in and it will not be necessary to switch on the light.
- I can install a solar geyser" (CCLW, L19-27).

To answer Question 3 the learners had to "gather data on the temperature in [their] kitchen over a period of seven days on the same time of the day and draw a line graph with [the] data. [They] needed to be able to discuss [their] findings with [their] classmates" (CCLP, L82-87). "The line graph was a failure. The learners haven't worked with line graphs yet. Due to a lack of thermometers they estimated the temperature. To raise or lower the temperature they all said one closes or opens the curtains" (CCLW, L28-31).

Not one learner completed Question 4 and 5.

In Question 6 the learners had to put together a glossary with all the solar energy concepts [they] have mastered (CCAL, 92-93). The words which they wrote were the following:

- "Solar energy
- Energy sources
- Greenhouse
- Solar oven
- Solar panels
- Solar farm
- Solar heating
- Solar energy" (CCLW, L34 – 42)

Quadrant 2 – learners engage with the concepts and show thinking skills

The teacher added that he "would have wanted that the learners give better quality of work to [me (the researcher)], but unfortunately it was not possible. The average mark was 12 out of 25" (CCLW, L43-44).

He "relied on the course materials at [his] disposal, namely the posters, the DVD and the manual. In [his] opinion the learners still don't understand solar energy. Although they have a vague idea of what it is and they know solar geysers. Most of the concepts and explanations were totally strange to them" (CCAL, L5-12).

In Table 18 a short summary is given on how the teaching strategy was plotted in the four quadrants of the Edwards learning task sequence.

Table 18: Case C summary on materials used for grade 8 Mathematics

Quadrant 4 Assessment of learning achieved	**Quadrant 1 Introducing and framing knowledge**
	Key concepts were introduced by the teacher on solar energy, (CCQ, L74), by making use of the DVD, poster, teacher's manual and the glossary (CEQ, L43). Unfortunately the planned visit to the solar plant didn't happen.
Quadrant 3 Enquiry and independent studies	**Quadrant 2 Learning activities to clarify concepts**
	Activity 1: Matching descriptions to graphs – group work Activity 2: Interpreting graphs – individual work Activity 3: Showing increase and decrease on graphs – individual (CCLP, L67-69) Investigation: A few learners completed an investigation on solar energy

Summary: Learning that has been supported by the learning material in Case C

The feedback received from the teacher on how he used the material showed that the learning material was mainly used to support knowledge transfer in Q1 where he introduced key concepts and revised what was already known for the learners, seeing that they were familiar with solar farms and solar geysers. It is not clear how he used the Mathematical activities provided in the material; there is no evidence of how the learners fared in completing them or that he commented on how the learners did when completing them. He mentioned in an interview that he used the activities provided in the material and the one in the lesson plan. The results of the assessment showed that he determined that not enough time was spent in Quadrant 2 and Quadrant 3 with tasks where learners could engage with the Mathematical concept of data handling, and exploring this in the local context of solar energy production. The investigation he did had the qualities of a summative assessment of Quadrant 4. He therefore jumped from

Quadrant 1 to Quadrant 4 with a summative assessment which did not have the desired results, because the learners have not engaged with the concepts sufficiently. As the learners knew it was not going to count for marks and it was only an activity to occupy them at the end of term, they did not engage with the Quadrant 3 enquiry.

Mathematics and Physical Science are slightly different to the other subjects in the sense that the Mathematical concepts support the renewable energy concepts and the teacher focused on the renewable energy concepts instead of the underlying and more basic Mathematical concepts.

5.3.4 Case D

Case D had a very detailed and sophisticated lesson plan, but this was not enacted, so I excluded it from the analyses. The lesson plan which I received was planned at the training workshop and was not realised in the classroom context. I tried to follow this up and very late in the research, Case D indicated that only an hour was spent on the learning material. One will have to look at what the constraints were in undertaking the kind of lesson that had been planned. This will have to be looked in further.

In Case D the materials were used by the teacher for grade 9 Natural Science learners. The data received from Case D is referenced as Appendix J. In Table 19: Background information Case D is given.

Table 19: Background information on Case D

<table>
<tr><th colspan="4">Background information on Case D</th></tr>
<tr><td colspan="3">Data Provided:
Lessons Plan, Questionnaire, Learner's work</td><td>Course Attended:
2016</td></tr>
<tr><td>Province:
Northern Cape</td><td>School size:
1086</td><td colspan="2">Socio Economic Context:
Poor background</td></tr>
<tr><td>Profile:
Boys & Girls</td><td colspan="3">Equipment available: Very little equipment available and it is difficult to teach in the overcrowded class</td></tr>
<tr><td>Subject:
Natural Science</td><td>Grade:
9</td><td>Class size:
45 -50 learners</td><td>Timeframe:
1 hour session</td></tr>
<tr><td>Medium of language:
English</td><td colspan="3">Resourced/Under-resourced school:
Under-resourced school</td></tr>
<tr><td colspan="4">CAPS:
Natural Science grade 9 Energy and Change</td></tr>
<tr><td colspan="4">Materials used: Watched DVD; printed booklet; PowerPoint presentations; employed teacher's guide; posters; glossary</td></tr>
<tr><td colspan="4">Learner Assessment:
Assignment on Energy</td></tr>
</table>

Description on how the learning material was used derived from the questionnaire, the lesson plan and examples of learner's work.

The teacher made the following remarks in terms of the context of his school. "Most of the learners in the school have reading difficulties which makes it more difficult for them to grasp simple concepts. Repeated explanations delay the progress in the curriculum execution" (CDQ, L15-18).

The materials were used for "grade 9 Natural Science in Energy and Change" (CDLW 6, 5, 4, 3, 2, 1).

The objective of the lesson was "to give learners an understanding on the use of solar power on a large scale and not only in homes" (CDLP, L6-7). The teacher used "all the available components of the RE teaching materials, [which included] the DVD, PowerPoint presentations, printed booklet, teacher's manual, posters and glossary" (CEQ, L19). The value that was added by using the above activities was that "learners were able to fully grasp the concepts and even explain their application to everyday life" (CDQ, L21-23). **Quadrant 1**

According to the teacher "everybody" responded "positively" to the DVD (CDQ, L28). Watching the DVD "created a personal impact on the learners on the issues affecting the environment" (CDQ, L30-31). **Quadrant 1**

The teacher indicated that he "used the following topics from the RE presentations: the greenhouse effect, climate change, renewable energy, non-renewable energy, the generation of electricity, solar energy, wind energy, hydro energy, biomass energy, geothermal and wave energy and energy efficiency" (CDQ, L32). The reason for using these topics was because, "most of the topics link with the curriculum". He stated that the reason for using these topics "was also to create awareness in the learners on issues affecting the environment" (CDQ, L34-36). **Quadrant 1**

The learners fared "good" in the assignment on energy consumption (CDQ, L24) (CDLW 1, 2, 3, 4, 5, 6). The teacher commented that "most of the learners got marks above the average mark" in completing the energy assignment (CDQ, L26-27). **Quadrant 2**

The teacher planned to also take the learners to the Sishen Solar Plant (CDLP, L36). In preparation for this visit (CDLP, L20) he planned to "introduce the different forms of renewable energy by asking learners to list them down in pairs. [He] asked learners to exchange papers and mark for each other. [The learners had to then] give feedback to the class. [The teacher also] recapped on

the different forms of renewable energy" (CDLP, L15-17). This was followed by a "question for [the] learners: [to] mention any areas [they] know of where there is large production of electricity using solar energy" (CDLP, L18-19)? He then "prepared [the] learners for the visit by stimulating their minds with the following questions and aspects:

i. What are you expecting to see at the solar power plant?

ii. Write down questions related to solar energy that you want clarity on even from your previous understanding of the working and use of solar energy" (CDLP, L20-25)

He "showed [the] learners the model of the photovoltaic cells that [he] once showed them in class and they should keep the concept of its use in mind. [The] teacher reviewed background information on solar energy being used to produce electricity in different ways" (CDLP, L28-31).

Quadrant 1

"Afterwards [he planned to] ask the learners to write a report on the visit to the solar power plant explaining how electricity is generated on a large scale using solar power, and state any concepts" (minimum of 3) that they learnt about (CDLP, L36-38).

The students will have to "do research, [to] illustrate and report on advanced solar energy technologies, such as on space satellites. The research must also include the pros and cons of solar energy. [He indicated that] the duration will be one week [and that the] "research will require use of several resources such as the library and the internet" (CDLP, L42-46). **Quadrant 3**

The teacher described the research project as follows: The "students will design and create a model or a working solar powered device". They can make use of the following "materials: the internet [and] "students supply materials with the assistance of the teacher in assessing the importance of the materials for the project" (CDLP, L51-57).

The "procedure" to be followed will be to:

- "review and discuss solar energy technologies,
- assign a week-long project of designing and creating a working solar powered apparatus or model.
- Students may work in groups or as individuals to develop and process the model" (CDLP, L.59-65)

He indicated that their "choices of projects may include:

- a concentrated solar collector for cooking,
- a model of a solar water heater with heat transferred from collector to water container to an output,

- a model demonstrating solar thermal electricity (with collector and rotating object representing a turbine)
- a model of a working PV cell device" (CDLP, L 67-74).**Quadrant 3**

"Evaluation [would] be done when the students completed the solar powered projects and presented them to the class. The teacher will "use a rubric to assess the models" (CDLP, L76-79).

Quadrant 4

For "further enrichment" he planned to "invite a solar energy specialist or representative from the department of energy for a class presentation on solar energy. The presentation must end with a question and answer segment whereby learners are free to ask the presenter questions related to what has been presented to seek clarity, or on any other aspect on solar energy" (CDLP, L83-87).

Quadrant 1

In Table 20 a short summary is given on how the teaching strategy was plotted in the four quadrants of the Edwards learning task sequence.

Table 20: Case D summary on material used for grade 9 Natural Science

Quadrant 4 Assessment of learning achieved	**Quadrant 1 Introducing and framing knowledge**
Evaluation [will] be done when the students completed the solar powered projects and presented them to the class. The teacher will "use a rubric to assess the models" (CDLP, L76-79).	Used the "DVD, PowerPoint presentations, posters, printed booklet, teacher's manual and the glossary" (CEQ, L19). Used the PowerPoint presentations on the following topics: "greenhouse effect, climate change, renewable energy, non-renewable energy, the generation of electricity, solar energy, wind energy, hydro energy, biomass energy, geothermal and wave energy and energy efficiency" (CDQ, L32), "created awareness" (CDQ, L34-36). Introduction to solar plant visit (CDLP, L28-31). For "further enrichment, invite a solar energy specialist" (CDLP, L83-87).
Quadrant 3 Enquiry and independent studies	**Quadrant 2 Learning activities to clarify concepts**
Research project: the "students will design and create a model or a working solar powered device" (CDLP, L51-74).	The learners fare "good" in the assignment on energy consumption (CDQ, L24) (CDLW 1, 2, 3, 4, 5, 6). Write a report on the visit to the solar power plant (CDLP, L36-38).

5.3.5 Case E

In Case E the materials were used by the teacher for grade 8 & 9 Natural Science learners. The data received from Case E is referenced as Appendix K.

In Table 21 a description on background information of Case E is given.

Table 21: Background information on Case E

<table>
<tr><th colspan="4">Background information on Case E</th></tr>
<tr><td>Province:
Western Cape</td><td colspan="2">School size:
110</td><td>Socio Economic Context:
Impoverished environment</td></tr>
<tr><td>Profile:
Boys & Girls</td><td colspan="3">Equipment available: Data Projector, Smartboard, Laptop, Document camera, Overhead projector, White board</td></tr>
<tr><td>Subject:
Natural Science</td><td>Grade:
8 & 9</td><td>Class size:
8-12 Learners</td><td>Timeframe:
4 weeks</td></tr>
<tr><td colspan="2">Medium of language:
English</td><td colspan="2">Resourced/Under resourced school:
Well-resourced school</td></tr>
<tr><td colspan="2">Special school:
For deaf and hearing impaired children</td><td colspan="2">CAPS: Third term: Energy and Change</td></tr>
<tr><td colspan="3">Data Provided: Questionnaire, Account of Lessons, Learner's work, Interviews (Appendix F)</td><td>Course Attended:
2013</td></tr>
<tr><td colspan="4">Materials used:
DVD; Printed booklet; PowerPoint presentations; Teacher's manual; Posters; Glossary;</td></tr>
<tr><td colspan="4">Learner Assessment:
Energy audit, Solar oven, Hay box, Visit to the MTN Sunstep Centre at SU</td></tr>
</table>

Description on how the learning materials were used derived from the questionnaire, the lesson account, follow-up interviews and examples of learner's work.

The teacher mentioned in terms of the context of her school that it is a special school for deaf learners. The teacher noted that, "The learners of my school are all hard of hearing or profoundly deaf. They vary in their ability to hear sound and in their ability to communicate with spoken language. It is an oral school for deaf children, so learners do not communicate with sign language. All learners communicate by speaking. The classes are small, but the abilities of learners vary. Some learners have other learning disabilities besides their hearing losses. [This] school for the deaf is a special school, but is one of only two academic high schools for deaf learners in the whole of the Western Cape Province. Being an academic high school, our learners have to meet all the same requirements in the CAPS documents (for various subjects) as learners from mainstream schools. Our learners write the same matric exam, ANA (Annual National Assessments) exams and any other standardized tests as students from mainstream schools. They find it difficult to watch videos without subtitles and depend on visual cues to understand the content of videos and spoken language" (CEQ L27-38).

The learning materials were used for two classes: grade 8 and 9 Natural Science.

For the grade 9 learners (CEAL2, L8) the teacher used the materials in the "Energy and Change" knowledge strand (CELW1, L1).

The teacher "started [her] lessons by showing [her] students the video/ [DVD] (CEAL1, L3), (CEQ, L43) it is a magnificent video" (CEAL1, L3-5) and the "majority" of the learners responded "positively" (CEQ, L64). "The value of watching the video was that "they enjoyed the video material and understood it to a large extent as [she] tried to explain the content by pausing the video" (CEQ, L50-52). "It was inspiring and valuable. Unfortunately it did not accommodate deaf learners by having subtitles" (CEQ, L67-68). **Quadrant 1 – new concepts are displayed by the teacher by making use of the DVD while learners engaged through meaning making**
The teacher used "all the available components of the materials on six topics" (CEQ, L43). The value added by using the different components was that "the students had the opportunity to see the solar power, hydroelectric power and wind power pictures on the PowerPoint presentations. This gave them the opportunity to [have an image] of the process of alternative energy sources in a practical way. Deaf learners often lack knowledge of the world and do not learn many things incidentally through communication with others or through overhearing significant others talking" (CEQ, L46-50). **Quadrant 1 – knowledge is displayed by the teacher by making use of the PowerPoint presentations as mediation tool, learners acquire new knowledge through the images.**

[Her] "second lesson was on the differences between renewable and non-renewable energy sources. The teacher "used the material to show images of renewable source electricity production and the greenhouse effect" (CEAL2, L8-9). To be able to do this, she made "use of the following PowerPoint presentations: the greenhouse effect, climate change, renewable energy, non-renewable energy, the generation of electricity, solar energy, wind energy and hydro energy" (CEQ, L71). The reason why she used these topics were, because "[these] types of renewable and non-renewable energy are current and growing in popularity in our country. In [her] opinion, these aspects should increasingly be the focus of [the] lessons" (CEQ, L77-79). The reason why she left out biomass, ocean and geothermal energy is because "the CAPS document does not really focus a lot on geothermal energy, biomass energy and ocean energy" (CEQ, L74-75). **Quadrant 1 – learners are introduced to new concepts**

The teacher "designed notes and an Energy worksheet for the learners (CELW1, L 2-25). [She] gave them four pages of notes which summarised global warming, making electricity at a coal power station, and the national grid and how it functions" (CEAL1, L5-7). In an electronic interview she mentioned that the researcher should "keep in mind that the [learners] struggle with language and can't read very well, so [she] had to modify some of the notes [the researcher] created to make it appropriate for them" (CEI1, L31-33). The notes were "followed by a question and answer worksheet in which they had to answer a few questions on what was taught so far" (CEAL1, L7-9). **Quadrant 2 – learners engaged through a tightly structured task where they have to engage with the new concepts.**

The teacher also did a "cost of electricity project" (CEAL2, L12-13) (CELW2, L 1-76) where she made use of the energy audit assignment which is an assignment developed for grade 9 Natural Science in the learning material. In her first account of the lesson, she mentioned that she "explained how to calculate the cost of using electrical appliances" (CEAL1, L9). "Once, [she] finished teaching this, [her] students [did] a mini project in which they compared the cost of using various appliances in their own homes. **Quadrant 2/3 – learners show engagement with tightly structured task and they had to apply key concepts and ways of enquiring.** This [was] followed by [an] online research on methods to save electricity. They [then recorded] their findings in the project" (CEAL1, L10-14). "Concluding Questions" (CELW2, L19-46) were added on the cost of electricity. The project also included an "Insulation case study on mushroom insulation [for] sustainable housing" (CELW2, L47-63). The final investigation of the project was to "evaluate the effective use of insulators in a house" (CELW2, L 64-76). **Quadrant 2/3 – learners engaged with new concepts and had to show thinking skills and engage with new concepts**

The learners visited "the MTN Sunstep Centre at the Stellenbosch University's Engineering faculty and assembled an electronic circuit called a light dark indicator circuit which forms part of the sustainability project. Students learnt how it saves electricity to have the lights switching on only when it is dark enough for it to do so" (CEAL2, L 13-17). **Quadrant 1/2 – learners are exposed to new knowledge and revisiting already known concepts**

She also mentioned that they "will still be building the solar cookers" (CEAL2, L19). **Quadrant 2/3 – open ended problem solving activity**

The teacher suggested that "perhaps in the future, a separate resource could be created for Natural Science teachers with less detail, but still having the appropriate diagrams of the latest technology in renewable energy" (CEQ, L107-109).

In Table 22 a short summary is given on how the teaching strategy was plotted in the four quadrants of the Edwards learning task sequence.

Table 22: Case E summary on materials used for grade 9 Natural Science

Quadrant 4 Assessment of learning achieved	**Quadrant 1 Introducing and framing knowledge**
The project: Calculating the cost of running different household appliances" (CELW2, L1-76) (CEAL2, L12-13) was used for summative assessment.	Key concepts were introduced by the teacher on the greenhouse effect, climate change, renewable and non-renewable energy, electricity generation, solar energy, hydro energy and wind energy (CEQ, L71).), by making use of the DVD, PowerPoints, posters, printed booklet, teacher's manual and the glossary (CEQ, L43). Speaker on solar energy and doing experiments (CEI3, L 7-14).
Quadrant 3 Enquiry and independent studies	**Quadrant 2 Learning activities to clarify concepts**
In the cost of electricity project, the learners did online research on methods to save electricity and they did a research question to evaluate the effective use of insulators in a house (CELW2, L 64-76 The teacher mentioned that they "will still be building solar cookers" (CEAL2, L19).	Learners completed an energy worksheet 1 (CELW1, L 2-25) and did a cost of electricity assignment. The learners visited "the MTN Sunstep Centre at the Stellenbosch University's Engineering faculty and assembled an electronic circuit called a light dark indicator circuit which forms part of the sustainability project. Students learnt how it saves electricity to have the lights switching on only when it is dark enough for it to do so" by building their own circuits (CEAL2, L 13-17).

The teacher also used the materials for grade 8 Natural Science (CEAL2, L4-9)

In the PowerPoint presentation on energy efficiency she "used slide 5 to show energy efficiency by design, slide 6 on recycling, slides 2 and 3 on solar heating and energy efficiency in domestic appliances" (CEAL2, L4-6). **Quadrant 1 – meaning making.** The learners designed and made heat retention bags and boxes. [They] cooked food in hay boxes (CEAL2, L6-7). **Quadrant 3 – students show agency.** In an interview, the teachers mentioned that the concepts she worked with are "using energy in a sustainable way. The hay boxes are used to cook food without a stove. Once the food is assembled and placed in the hay box in a pot with a tight fitting lid, it cooks by itself. The pot of food is heated to boiling point on a stove, before placing it in the hay box; it continues to

cook using the heat energy that is already in the food. This is called heat insulated cooking. This is a great way to save energy because you are not using electricity to heat the pot of food for the full duration of the cooking time" (CEI4, L20-27).

In Table 23 a short summary is given on how the grade 8 teaching strategy was plotted in the four quadrants of the Edwards learning task sequence.

Table 23: Case E summary on materials used for grade 8 Natural Science

Quadrant 4 Assessment of learning achieved	**Quadrant 1 Introducing and framing knowledge**
	Key concepts were introduced by the teacher on energy efficiency (CEAL2, L4-6)
Quadrant 3 Enquiry and independent studies	**Quadrant 2 Learning activities to clarify concepts**
The students designed and made heat retention bags and boxes. [They] cooked food in hay boxes (CEAL2, L6-7)	Students designed heat retention boxes (CEAL2, L6-7)

For enrichment purposes the teacher invited a speaker to the school: "[The speaker] brought solar (PV-photovoltaic) components and circuit components, gave a talk on solar power and did an experiment with the grade 7 to 9 learners at [the] school involving ammeters, voltmeters, solar PV panels (tiny ones) in which they built small circuits measuring the voltage and current with the tiny solar panels in the circuit. [The teacher] invited her because [their] school signed an eight year contract with the company that [the speaker] works for in which they rent [the school the] PV systems and we pay them for it over a period of 8 years. [The speaker also] took the students on a tour to view the panels and spoke about how they work" (CEI3, L 7-14).

Summary: Learning that has been supported by the materials in Case E

This account illustrates that knowledge was displayed by the teacher and learning supported in Q1 to introduce learners to new concepts through the use of the learning materials. An advantage of the images in the learning material for the deaf learners was that they could engage with key concepts from a visual point of view, because they have to rely on images for understanding and mastering.

The teacher scaffolded the learning progression to support independent enquiry in Q2 and Q3. Not only were learners introduced to new concepts but she also provided the leaners with activities and enrichment experiences in these new concepts, for example in the energy audit assignment, the visit to the university and the building of hay boxes where they engaged with

energy saving measures. They also had opportunities to do research on these new concepts, for example measures to insulate a house. Learners were also assessed on this new knowledge acquired which supported Q4 for summative assessment.

Value added for the teacher in the use of the learning material:

The value for deaf learners was that they were able to see how the different technologies work. This gave them the opportunity to have an image of the process of renewable energy sources in a practical way. Deaf learners often lack knowledge of the world and do not learn many things incidentally through communication with others or through overhearing significant others talking. Watching the DVD was inspiring for the learners and they enjoyed it; unfortunately it did not accommodate deaf learners by having subtitles and depended on visual cues to understand the content of videos and spoken language.

5.3.6 Summary and conclusion

The feedback on how the learning material were used by teachers indicated that the material was used to a certain extent in all four quadrants, although the material lends itself more to Quadrant 1 where knowledge was displayed by the teacher as they modelled and instructed key concepts through the use of the DVD: 'Planet Earth, a Living Heritage', the posters and the PowerPoint presentations.

Three of the five cases used the energy audit assignment which corresponds to the CAPS Natural Science third term requirements. The learners engaged with the tightly structured task which demanded engagement with key concepts. Case A added a column on cost and it was used in Q4 as a CASS activity; in other words, learners were graded on the assignment and it became a summative assessment. Case E restructured it for her deaf learners, added a cost analysis, had learners research energy saving measures, and she added two more questions of which the one was an investigation on insulation for housing. In this case, it also became a summative assessment as the learners were graded on the total project words. Case B used it as a formative assessment where learners had to show thinking skills and respond to the task demands, taking control and exploring what they can do. Only some of the learners completed the audit, but it served as an 'eye opener for the rest of the class and it gave the rest of the project momentum. One needs to observe that teachers tended to use an activity in Q2 but it is then graded and used for summative assessment in Q4 as well.

The subject-specific assignments were implemented very well for Cases B and E. Case B used two of the Geography assignments which form part of the learning materials, Koeberg and Cape Recife Wind Farm. The report showed that learners were exposed to new knowledge and engaged with the tasks in Q2 and independent inquiry which supported agency in Q3. In other words the tasks had the quality of moving between Q2 and Q3. These assignments also encouraged learner involvement and group work very well. Case B then used these assignments in Q4 as summative assessment. Case A developed an open task for her learners on renewable energy sources, but she was disappointed on how they completed the task.

The building of hay boxes as in Case E was an illustration of using energy in a sustainable way. The hay boxes were used to cook food without a stove. This was an example of Q3 where learners engaged with the newly found concepts of heat insulated cooking. She also mentioned that the learners will still 'build solar cookers', but there is no evidence of this.

Evaluating the cases, the material supported use in Q3, but only to a certain extent and the one open task where learners had to show agency did not have the desired results. Data was also not gathered to determine whether the teachers used the renewable energy concepts in, for example, examination papers for summative assessment in Q4.

Summary on the value added for teachers

Value that was added for teachers by using the different components of the learning material was through the link with CAPS where value was added to the learners' conceptual knowledge on renewable energy. The inclusion of South African images and examples spoke to the learners' world and aided the scaffolding process. The extensive use of images gave learners and especially the deaf learners the opportunity to 'see' how the different technologies work. The lesson assignments are written in a way that learner involvement and group work was implemented very well.

In conclusion one can see that the patterns of use of the learning material were applied effectively in all four quadrants in the above cases, although the material tends to lend itself more to some quadrants than to others. One could identify learning tasks that build on one another and which make it possible for learners to become familiar with new content, ideas and concepts in such a way that they internalise the content and reach specific goals. One also needs to note that it didn't seem possible to use the learning material in all four quadrants in each case, and that learner-led work will need augmentation.

Chapter 6 An Analysis of Materials Used and Learning Sequences Evident

6.1 Introduction

The Renewable Energy Schools' Programme was developed to address the socio-ecological issues and risks of climate change and the accompanying environmental impact, as well as the need for a sustainable energy supply in South Africa. The primary reason for the development of the renewable energy learning material was to empower teachers with sound knowledge. The intention was to enable them to effectively facilitate learning about climate change and how renewable energy can help counteract climate change (1.2) and lead to sustainability (2.2). This was attempted by broadening the knowledge of teachers on renewable energy through workshops, and providing them with appropriate content material to ensure effective implementation in the classroom (1.2.4).

The learning material was thus developed as a tool which teachers could leverage to creatively fulfilling their own needs in terms of 'how' they teach and scaffold learning interactions, complying with the relevant subject curriculum requirements. As part of the workshops, the learning materials and various ways of using the materials were discussed (4.5.2).

In Chapter 1, the research question was posed on how the learning materials have been developed and support classroom use (4.5). The research focus was to determine how the learning material has been used within teachers' lesson sequences in different subject areas (5.3.1, 5.3.2, 5.3.3 & 5.3.5). To map the patterns of use in relation to learning, the Vygotskian-based Edwards learning task sequence was used as an analytical framework to inform the project going forward (2.4).

From the detailed data descriptions of Chapters 4 and 5, a number of analytical statements were deduced from the evidence of the material development and use to support learning. These statements are expanded in this chapter.

6.2 Analytical Statement 1: The development of the learning material was effectively informed by interactions with teachers, considering the development of South African renewable energy industry

It is clear that the development and update of the material were informed not only by the teachers but also from the development that took place in the renewable energy industry in South Africa. As the programme matured, the ongoing material development and updates attempted to act on the observations in the pilot study (4.2.6) and the feedback received from teachers (4.3.2) in order to strengthen the conceptual knowledge of teachers and learners on renewable energy. The development that took place over the years was, amongst other, defining of concepts which led to the compilation of a glossary in 2009 (4.3.1), the design of appropriate posters due to lack of data projectors in 2013 (4.4.1), and the development and improvement of subject specific activities in 2015 (4.5.1). The evidence showed that the value that was added for teachers and learners was that their understanding of sustainable and renewable energy, climate change and how to reduce negative environmental impact from energy use increased (5.3.2, 4.4.2, 4.5.4).

Due to the progress made on renewable energy as mainstream energy, as reported in REN21 (2016) (2.2.4), the necessary adaptations to be part of the learning programme were made in 2016, so that the learning material is an up-to-date, sophisticated and comprehensive resource on renewable energy (2.3.1, 4.5.1). The feedback from the teachers (5.2.1) also indicated that they find the participatory approach in the development of the materials between case engineers and teachers of value.

Quite a number of the teacher's responses also related to the visual aspects of the materials which contributed to the mediated learning of the concepts for learners (4.4.2, 4.5.3, 5.3.1, 5.3.5) of which the benefit to the deaf leaners stood out.

One thing that occurred repeatedly throughout the years was teachers asking for more subject specific activities (4.4.2, 5.3.1, 5.3.5). From the evidence in Chapters 4 (4.4.2) and 5 (5.3.1, 5.3.3, 5.3.5) it seems that teachers need guidance on how to engage learners with the new concepts on renewable energy (5.3.3). Thus when they asked for activities (4.4.2), they not only asked for summative assessments but also for tasks which demand engagement with key concepts (substantive knowledge) and ways of enquiring (syntactic knowledge) (O'Donoghue, 2015). This could be an indication that not only are teachers finding it difficult to incorporate new

environmental knowledge in the curriculum but they also want guidance on how to develop activities for engagement with these new concepts.

Grade 9 Natural Science teachers mentioned that they used the learning material but they find it too comprehensive and asked for another resource only for Grade 9. I will argue against this because for a teacher to develop professional expertise it requires them to take the materials into pedagogical use and not to just use the material as they are pedagogically designed.

From the above it is clear that the development of the learning material is a dynamic and an ongoing process, and it is important for an ongoing reflexive review of the development and use of learning material, as well as specified feedback from teachers on how they have used the material and how the materials might be usefully adapted, as pointed out by Russo and Lotz-Sisitka (2006) (2.3.2).

In conclusion it was found that the material developed over the years to address various needs of teachers not only adds value to their understanding but also aids their teaching of renewable energy. A recommendation will be that the material development should keep on reflecting what is happening in the renewable energy industry, supported by regular updates of the materials and the development of more subject-specific activities which helps teachers to engage learners with these new concepts.

6.3 Analytical Statement 2: The implementation of the renewable energy learning material accelerated in response to the inclusion of renewable energy as a curriculum topic

The majority of teachers have been able to selectively adapt the material to their curriculum needs (4.4.2, 4.5.3, 5.3.1, 5.3.2, 5.3.3, 5.3.5). In this study the learning material was used in four curriculum learning areas, namely Geography grade 11, Life Sciences grade 11 and 12, Natural Science grade 8 and 9, and Mathematics grade 8 (4.4.2, 5.2.1). What came as a surprise was how well the learning material could be used in Life Science grade 11 and 12 and how well the learning material can be adapted for Life Science grade 10 (5.3.1.). The value therefore is that the national curriculum can be enhanced in specific subject matter (4.4.2, 4.5.4, 5.3.1, 5.3.2, 5.3.3, 5.3.5).

The conceptual linkage between these subjects is climate change and the associated increase in the negative greenhouse effect (2.2.2, 5.3.1, 5.3.2, 5.3.3, 5.3.5); one way to address this is through the effective use of renewable energy (2.2.4). All the subjects emphasised that switching from fossil-based energy use to renewable energy sources can counteract climate change (5.3.1, 5.3.2,

5.3.3, 5.3.5). In other words, the evidence shows that environmental education is strengthening as environmental concerns are appearing as topics in the curriculum and this opens the possibility for teaching education for sustainable development.

What is interesting is that the same material could be used in different subjects to address the needs of teachers for the information on renewable energy, indicating a clear need for information on the topic. The opinion writer David Orr referred to the education curriculum as something which we have taken apart in bits and pieces, calling it disciplines and sub disciplines and he said that it is a myth to think that we can sufficiently reconstruct it again. He further states that learners finish school without a holistic integrated sense of things (Orr, 2004). In the light of this view, the renewable energy learning material is directed towards a more inclusive approach, with teachers confirming that the material is generic enough so the resources can be used across a number of different subjects.

Most respondents over the years indicated that the workshop was the first training they have received on renewable energy (4.4.2, 5.2.1). This confirms the need for new environmental knowledge to be introduced to teachers, as they are expected to teach these new topics in which they have no formal training (2.3.2). In addition, they need material they can work with to supplement the new environmental knowledge, as also evidenced in the development of the Fundisa for Change learning material.

Evidence also showed that teachers valued and appreciated the learning material they received (4.4.2, 4.5.4, 5.2.1) because it is a comprehensive resource on renewable energy and could therefore be also be used as a reference, seeing that the textbooks do not provide enough information on these topics (5.3.1, 2.3.3) as is also confirmed in the UNFCC report (Lotz-Sisitka et al., 2016).

The focus of the use of the material was not only on the environmental side of renewable energy but also on the social and economic aspects, like access to clean energy and job creation as indicated by the teachers (2.2.3, 5.3.2). This addresses two of the SDGs namely: Goal 4: *Quality Education* and Goal 7: *Affordable and clean energy for all* (2.2.4).

In conclusion, it can be determined that the learning materials addressed the emerging theme of climate change and that the subjects dealt with the conceptual knowledge and raising of awareness in the environmental and social aspects and consequences of climate change.

The following statements are based on the Edwards learning task sequencing.

6.4 Analytical Statement 3: The materials were primarily used by teachers to display knowledge and to develop key concepts on renewable energy.

It clearly emerged from all four cases reviewed that the combination of visual and written information of the DVD: 'Planet Earth, a Living Heritage, the PowerPoint presentations, and posters were used to develop the learners' knowledge and their understanding of new concepts on renewable energy. These gave the learners a visual experience of the concepts and provided opportunity for revisiting what is already known (2.4.2, 4.5.4, 5.3.1, 5.3.2, 5.3.3, 5.3.5).

The pattern of use is firstly to watch the DVD as an introduction to understand that our planet is under pressure and that our current lifestyle is part of the pressure and not sustainable. To make it possible for future generations to continue living here, we need to become aware of how we live, address certain issues, and become more sustainable (2.4.2, 4.5.4, 5.3.2, 5.3.3, 5.3.5). (Q1)

After the DVD, teachers used the PowerPoint presentations which reinforced the concepts through more detailed information on the specific topics. The concepts were mediated through written information and the extensive use of images and animations. The PowerPoint presentations chosen in the different subjects were all CAPS related, with almost all the topics chosen namely, energy (greenhouse effect and climate change), electricity, solar-, wind-, hydro-, biomass-, ocean energy and energy efficiency (2.4.2, 4.5.4, 5.3.2, 5.3.3, 5.3.5).(Q1)

The knowledge gained from the presentations was then revisited when learners related to the posters. The continuous display of the posters in the classrooms also increased the possibility of incidental learning. The value of the visual representations contributed furthermore to the understanding and comprehension of knowledge on the subject of renewable energy, as well as the South African context to which learners could relate, giving them hope (5.3.2).

This pattern of use of the DVD, PowerPoint presentations and posters seemed to have represented the content knowledge on the greenhouse effect and renewable energy to learners in all of the subjects (2.4.2, 4.5.4, 5.3.1, 5.3.2, 5.3.3, 5.3.5).(Q1) Hereby, the learning material addressed the aim of CAPS in deepening knowledge (Schudel, 2010).

In conclusion it seemed that, in line with CAPS requirements, knowledge was displayed by the teacher through the use of the DVD, PowerPoints presentations and posters to model and instruct

key concepts and that learners could make meaning through the concepts being reinforced with these mediation tools.

6.5 Analytical Statement 4: The learning materials were used more effectively to scaffold learning progressions in some cases and subject areas than others

How the material was used in the different subjects will now be discussed separately.

6.5.1 Geography

The learning material was incorporated through the Geography questioning method, which is part of the Geography curriculum, to scaffold task sequencing from mediated introductory inquiry to solution-orientated narratives (5.3.2).

The new found knowledge from the visual exposition of the DVD, PowerPoint presentations and posters (Q1) was followed by the use of the energy audit assignment to clarify concepts where learners had to engage with the activity to get clarity in this new found knowledge (Q2).

From the reported evidence it was only in Geography where the energy audit assignment was used as a formative assessment where learners could engage with the new concepts and had the freedom to still make mistakes (Q2). Although only some completed this activity and only some responded to the task demand, it served as an "eye opener for the rest of the class" which "gave the project momentum" (5.3.2). In other words even those who did not do the activity understood the effect and implication of energy use on our environment thereby showing that they made meaning and developed thinking skills (2.4.2). (Q2)

The patterns of use identified in the two assignments, namely Koeberg and Cape Recife Wind Farm, were that they provided real-world contexts and issues, in terms of the development of a wind farm close to Jeffreys Bay and the consequences of an earthquake in the Koeberg Nuclear power plant region, from which skills and concepts could be learned and developed. (Q2/3)

The two activities facilitated learning in terms of the following (5.3.2):

- The activities are designed in such a way that they supported Q2 activities to clarify concepts and Q3 enquiries in the sense that learners engaged with concepts in Q2 but the assignment was scaffolded in such a way that it moved from inquiry to more learner-led work where learners have to engage with the acquired facts and develop their own opinion, thereby showing agency (2.4.2). (Q2/Q3)

- The design of the questions in the activities was done in such a way that learners had to accomplish different cognitive levels and therefore it could be used as a summative assessment at the end (2.4.2). (Q4)
- The inclusion of internet links which learners searched on their mobile phones in class proved to be valuable because it led to more learner participation than normal (4.4.5). Q2/Q3)

Independent thinking is required in the Education for Sustainable Development programme (2.4) and the above showed that learning progressions were scaffolded with the learning material and that learners took control of the knowledge that they have acquired and showed agency.

Value added for the teachers by making use of the material was that individual and group work was better facilitated compared to standard learning activities (5.3.2). The e-learning strategy incorporated in the Geography assignments facilitated learning in the sense that it was a natural extension for learners from the technological environment in which they operate daily (5.3.2) and the teacher found this very positive. Learners were also exposed to the possibilities of jobs in the renewable energy sector (4.5.4, 5.3.2) (Q3). Part of the Geography curriculum is to ask 'what can I do' and learners could identify this and thereby show agency (5.3.2)(Q3).

It can be asked whether the learning material provided for teacher professional development. I present yes, as teachers had to apply skill and insight to put into use the learning material through the Geography questioning method and employ the insight through all activities and topics. The teacher had to show competence in both his own teaching ability and his subject knowledge to utilise the learning material so well and therefore I conclude that teacher professional development did take place.

In conclusion the learning material supported a clear learning progression and provided for all four learning task sequences to be scaffolded in Geography.

6.5.2 Natural Science

The pattern of material use which emerged in Natural Science was that a clear learning progression was scaffolded in both Cases A (5.2.1) and E (5.2.5). In both cases the DVD, PowerPoint presentations and posters mediated the introduction of new content knowledge and concepts. (Q1)

Case E mediated learning through the handouts and worksheets; these short formative tasks and activities showed that the learners engaged with key concepts through tightly structured tasks on

energy generation and where it was expected, they took control of the new knowledge and explored what they can do with it (5.3.5). (Q2)

The pattern of use for the energy audit activity in both Cases A and E was that the teachers adapted the assignment and used it creatively to suit their own teaching needs. It was therefore not only an activity where learners engaged with the newly found concepts they were introduced to (Q2) in the materials, but also could be used as a tightly structured task to formatively assess the new knowledge gained on energy use. The activity also mediated the connections between what was already known and new concepts that the learners were encountering (Q2), like electricity cost (Case A) and energy saving through the effective use of insulation (Q3) (5.3.5). The investigation added by Case E to the activity on the effective use of insulation gave the learners the opportunity to do research and therefore show agency. (Q3) In both cases the learners were graded on the acquired knowledge and thus it became a summative assessment (Q4).

Case A included an open ended task where learners had to apply the concepts they have learned (Q3). Unfortunately the result was that some learners received help from their parents or took the information directly from the internet (5.3.1).

Learning was further enhanced in Case E (5.3.5) when the concepts and theme of the term were revisited on a field trip where learners engaged with the building of energy saving technology (Q1/Q2), and enjoyed a speaker visiting their school explaining the photovoltaic system of the school.

The grade 8 learners engaged with the concepts of retaining heat and showed agency by building hay boxes to cook food (Q3), thus using energy in a more sustainable way.

In conclusion the learning material scaffolded learning in all four learning task sequences in Natural Science to a certain extent, although Quadrant 3 needs more attention to support the learning progression towards learners showing agency.

A recommendation will be to enhance Quadrant 3 more, but to get the desired learning progression of learners having to take agency, one will have to design the research projects carefully. Lifelong change will only be reached through knowledge gained from open tasks where the learning material empowers learners with skills to address sustainability issues (NAAEE, 2004) (5.3.1).

6.5.3 Physical Science

The evidence showed that the patterns of use in Physical Science were the introduction of new knowledge and key concepts to learners through the use of the DVD, PowerPoint presentations and posters on the applicable topics covered in the curriculum (5.3.1). Knowledge was displayed and learners were introduced to these new concepts. (Q1) A valuable link to reinforce learning was made to a school that made use of biofuel to cook their lunch, thus the learners experienced a practical use of renewable energy which can be applied to everyday life.(Q1) Learners were also introduced to further study possibilities in engineering relating to renewable energy.

In conclusion, the pattern of use which occurred in Life Science is that the learning material was mainly used for the introduction of new concepts. A recommendation will be to develop subject specific activities for Physical Science which scaffold learning through the task sequencing framework and strengthen learner's understanding of renewable energy.

6.5.4 Mathematics

According to the lesson plan the specific aim was to understand and grasp solar energy. Learners were exposed to renewable energy concepts through the use of the DVD, PowerPoint presentation and the poster on solar energy. According to the view of the teacher, the value in this case was that learner's knowledge and understanding of the solar plant close to them increased.

The content area in which the solar energy was presented was measurement and data handling and learners engaged with these key concepts in the three activities provided in the learning material (5.3.3). Unfortunately there was no evidence of this engagement. From the teacher's account on how learners fared when completing the investigation (Q4), it is clear that the learners grasped some understanding of the solar concepts but learners did not show understanding of the measurement and data handling concepts. This could mean that the activities either did not facilitate learning, that the setting in which they were used was not conducive for learning, or that not enough time was spent with the activities to establish the concepts (Q2) to make it possible for them to use the new knowledge in the summative assessment (Q4).

What emerged from the use of the Mathematical activities in the learning material is that much more thought still needs to go into the use of the learning material on renewable energy in relation to Mathematics activities. It is also clear that one should engage more specifically with the teachers in the workshops on how to integrate the learning material in their lessons. Therefore a

clear cut conclusion on the renewable energy learning material as part of the curriculum of Mathematics is not possible and should be explored further.

6.6 Analytical Statement 5: The renewable energy materials were used to facilitate learning through diverse task sequences in a range of school subject areas.

What emerged from this research was a broad sense of how the learning material was used to facilitate learning through differing task sequences in a range of school subject areas. For ESD, it is important to note into which quadrants the activities fall, to meet the learning requirements of the ESD programme.

The evidence showed that knowledge delivery (Q1) is supported very well by the provided learning materials. The DVD, PowerPoint presentations and posters presented demonstrated the necessary new knowledge on renewable energy and focused on the key concepts through the extensive use of images in combination with written text (5.3.1, 5.3.2, 5.3.3, 5.3.5). In this regard the deaf learners' understanding of the material and key concepts needs to be emphasized (5.3.5).

The evidence showed that the teachers were able to scaffold learning tasks which demanded of learners to engage through meaning making, show thinking skills and respond to tightly structured tasks where they could explore what they can do. Teachers used questions to scaffold the learning processes (5.3.2; 5.3.3; 5.3.4) and some concepts were presented by the teacher and some by learners (5.3.2).

Evidence where learners engaged with tightly structured tasks which demanded engagement with key concepts (Q2) emerged from Case B and Case E (5.3.2, 5.3.5), where Case B made use of the energy audit activity and Case E designed a formative assessment where learners engaged with the key concepts they were introduced to in Q1. This assessment indicated that learners are starting to make the connections between already known and new concepts.
Q3 implied higher order thinking skills and open-ended, independent problem solving activities where learners took control of the knowledge they have grasped and used it to solve problems, the exact intention of ESD.
It is clear that the assignments used by Cases A and E (energy audit) and Case B (Koeberg and wind farm) (5.3.1, 5.3.2 and 5.3.5) cannot be allocated to one quadrant only, because it had elements from all three quadrants. Learners engaged with the key concepts (Q2) and the assignment allowed learners to show agency to a certain extent (Q3) where they had to apply thinking skills,

but in none of these cases did the learner take responsibility for their own learning, as it was still teacher directed. Case A's research project on renewable energy sources was the only activity where independent learner-led inquiry could take place, but unfortunately the results were unsatisfactory as discussed earlier (5.3.1).

From the evidence in the above-mentioned cases, the activities were all used for summative assessments, Q4, where learners displayed their knowledge and were graded on acquired tasks. Unfortunately the assessments were similar to the use of learning activities to clarify (Q2) and test key concepts (Q4).

It is clear that the following task sequencing patterns emerged: Q1-2 where the teacher presented the new knowledge and the learners clarify the concepts through activities. In Q2-4, where the learners worked with the concepts and their understanding is tested in Q4, both these patterns occurred often. Q2-3 occurred through activities where there was a research aspect to it. The evidence showed with the energy audit as well as the Koeberg and wind farm assignments that learning took place in a combination of the different quadrants, such as Q1-2-3, Q2-3, Q3-2 and Q2-4.

Specifically for ESD, it is important to note that some quadrant patterns are more desirable than others. It is not so much activities in a single quadrant that is as important as the combination of quadrants that are important for ESD learning. For ESD, Q3-1, Q3-2 and Q3-4 are especially important due to the learner-led component of this quadrant combination. From the evidence it is clear that teachers are using the learning material for knowledge purposes and that the activities provided in the learning material scaffold a clear learning progression through the four quadrants, but more attention is needed in the development of learner-led work to provide for ESD.

6.7 Analytical Statement 6: There was evidence of the acquisition of knowledge and learning processes that are indicative of ESD processes in the curriculum

The material has been developed to create opportunities for learners to learn about renewable energy and its role in sustainable living (1.2). The data mapped against the Edwards learning task sequences showed how the material scaffolded a learning progression and that ESD is actually taking place.

For learning to be classified as education for sustainable development, the important thing was the balance between the teaching of the knowledge, the exploration of the concepts and the

action taken with the concept knowledge. Activities should therefore take place in all of the quadrants that Edwards mentions (2.4, 2.4.2).

From the evidence it seemed that the learning material provided adequate support for the acquisition of knowledge and for the explanation of the core concepts on renewable energy as well as testing these concepts through a summative assessment, which mainly supports Q1, Q2 and Q4 (5.3.1, 5.3.2, 5.3.3, 5.3.5). One can therefore conclude that Q1, Q2 and Q4 were sufficiently covered, but the query remains on whether Q3 was covered sufficiently.
Because good Q3 work represent acquisition of knowledge and concepts which leads to participation and learner –led agency (2.4, 2.4.2), sufficient deliberative engagement with energy use in the home, school or South Africa as a whole, is important for work to be defined as education for sustainable development.

To indicate whether learners adequately engaged with future sustainability outcomes in energy use patterns in South Africa, the various engagements which qualify for Q3 will now be discussed.

One of the examples of Q3 engagement is that three of the four cases did the energy audit assignment where learners had to measure the energy use of different electric appliances at home and discuss the **economic** and **environmental** impact of energy use in their homes. Thus, they engaged with future sustainability issues (5.3.1, 5.3.2, 5.3.5).

Another example of Q3 engagement was the Geography assignment where learners engaged with the scenario of an earthquake at the Koeberg nuclear power plant. Learners had to map buffer zones and determine evacuation routes out of Cape Town, taking into account the possibility of a tsunami. Learners also had to identify possible job opportunities in disaster risk management. This showed engagement with the **social** and **environmental** consequences of an earthquake. In another assignment, learners had to write a report for a wind farm developer where they not only had to determine whether the wind source is sufficient but also the **environmental and social** impact of wind turbines being built in the specific area (5.3.2).

From the evidence in Case E, learners (5.3.5) ate soup which was cooked in the hay boxes that they had built; they experienced alternatives to our normal energy use patterns through heat insulation cooking.

From the above it can be seen that learners engaged with sustainability concepts and had to do something with the concepts they acquired.

Case A was the only one where learners engaged with an open task on renewable energy technologies (5.3.1). The results were unsatisfactory because learners copied directly from the internet or received help from parents. This can be an indication that learners are not ready or used to engage with open tasks and do this type of research. This also shows the inability of learners, teachers and parents to engage with learner-led change. This means that all the parties will have to be educated on what learner-led inquiry is, its importance to ESD, and how it is addressed. Possibly learners will have to be prepared over a longer period of time to engage with open tasks. One also needs to note that the teacher-directed activities had a more positive outcome, as could be seen above.

One of the main results required from ESD is evidence of behavioural change and subsequent action.-In this case, there was no evidence of behavioural change or learners taking action, such as directing an energy savings campaign for example. However, without people learning new knowledge (Q1), without learners doing activities to clarify and understand this new knowledge (Q2), and without learners thinking about the effects of the knowledge relating to future energy use and the personal impact of non-sustainable energy use (Q3), then it is highly unlikely that learners will change habits and develop sustainable actions (Q4).

Bob Stevenson said that the school curriculum is not the place to expect actions to be taken to save the planet; the school curriculum is about learning and using the knowledge in meaningful ways. He proposes a mismatch between what people are trying to achieve with ESD and what the curriculum is set up to practically enable (Stevenson, R., Brody, M., Dillon, J., & Wals, A., 2013).

The ESD defining question should therefore rather be is the knowledge contributing to learning and change? By fixating only on the action step required for ESD, learners are missing out on gaining knowledge and the understanding of things. One of the aspects of Vygotsky's notion of zone of proximal development is where learning instruction moves ahead of development, this leaves us with the idea that learning is a progression. According to Zaretskii (2016), one step in learning can involve multiple steps in development, meaning that learning can be at multiple and different levels before agency can take place.

In conclusion, the evidence showed that, through the use of the task sequencing, the learning material is producing learners who are going to potentially be able to use what they have learnt in relating an energy lifestyle to future sustainability in the country.

6.8 Conclusion

It can be concluded that the learning material provided knowledge delivery on renewable energy and that the activities of some subjects deliver learning more effectively than others. It is clear that the materials added value for teachers in their teaching practices as well as towards learners' understanding of renewable energy. Value was also added to the programme going forward in understanding how the teachers are using the material and what they found valuable, with suggestions on further beneficiation.

Chapter 7 Conclusion

7.1 Introduction

This chapter provides an overview of the research findings, with recommendations on how to develop and enhance the schools' programme further. The intention of the study was to inform how education for sustainable development can be strengthened in terms of the current renewable energy learning material, teacher professional development, and classroom practises. Further, the research process is reviewed and recommendations for future research are made.

7.2 Summary of Research Findings on Patterns of Use

The research revealed how the development of the learning material is a dynamic process between material development, teacher professional development, yearly monitoring and evaluation. This leads to feedback on patterns of use, and the subsequent adaption of materials, leading to the development of a comprehensive resource for teachers on renewable energy. The study also probed how the materials relate to the future sustainability of South Africa's energy supply and how education on the use of renewable energy might lead to counteracting climate change.

The findings of the research were reviewed and discussed against cases of the use of the learning material in different subject areas. The patterns of material use identified through the learning task sequence will be discussed, as well as how this information will influence future material development, the Teacher Professional Development workshops, the expansion of networks and the funding of the programme. The value that was being created by the materials and the extent to which the value that was being created is an ESD process and the different areas that are affected will also be discussed.

7.3 Curriculum use

The materials were used in four subjects, namely Geography, Life Sciences, Natural Science and Mathematics. The main reason for teachers using the learning material is the link between the knowledge and the CAPS curriculum. The conceptual linkage between the subjects in which the materials were used is climate change and the consequences thereof. This is centred on exploring ways to counteract climate change through the use of renewable energy. In the case evidence reviewed, the renewable energy learning material was seen as a generic resource that could be used and was of benefit to different subjects of the national curriculum.

A recommendation for future materials development and implementation is to focus on Life Science as well, and to determine which other subjects could also benefit from the learning material, for example Economics or Business Science.

7.4 Patterns of Use to Support Learning

Determining the patterns of use to support learning was undertaken with the Edwards Learning Task Sequence framework. This proved to be a sound, helpful and positive framework for analysis of reported cases of use in evidence of lesson planning and student work in the diverse cases selected for review. It shed light on how the patterns of use translated into developmental learning sequences that could be read as processes of education for sustainable development in the curriculum settings.

The results showed that the DVD, PowerPoint presentations and posters were primarily used by teachers to introduce learners to key concepts and to broaden knowledge on renewable energy. It was evident that the learning materials are knowledge orientated and the teachers have used them to derive knowledge personally and to present knowledge to the learners. The activities provided in the learning material scaffold a clear learning progression but, in terms of the learning processes, the task sequencing showed that the activities are not orientated strongly enough towards learner-led enquiry as a key process in ESD. There was evidence of learners taking cognisance of the content, clarifying the concepts in terms of energy use, and starting to reflect on future sustainability in South Africa at a national level as well as their own energy lifestyle. The analysis of the curriculum work appears to indicate learner-led work and agency which further indicates that ESD can be strengthened more to bring about even greater behavioural changes.

A recommendation for the future development of activities will be to keep in mind which activities support which quadrants as the combination of the quadrants is important for ESD learning. More focus must go into the development of learner-led inquiry work where learners are required to show agency and where they acknowledge and engage with their own energy lifestyle.

7.4.1 Inform further development of the materials

It was concluded that material development is an ongoing process and regular updates to the materials were beneficial. It also appeared that the development of the learning material was revised continually and the participatory approach between experts and teachers was of benefit. The learning material is sufficient in terms of knowledge on renewable energy and providing CAPS information for the different subjects.

This research showed a need for subject-specific activities that can be utilised by teachers to scaffold the learning progression through all four quadrants. The Geography activities and assignments managed to facilitate a well thought out learning progression. Thus, after analysing how the material was used in this subject, a recommendation is to develop activities for other subjects along the same pattern as the Geography assignments.

The inclusion of the e-learning strategy in the Geography assignments seemed to work very well and a recommendation is to rather design an e-learning strategy for each subject's activities instead of trying to develop a separate e-learning platform, as was described in Chapter 4.

Separate research suggestions should be added to the learning material for all the subjects, but thought is needed here to propose not only further education for sustainable development but also to encourage learners to take responsibility for their own learning.

Another recommendation is to add practical equipment to the resource to meet differing learner abilities.

Due to the feedback from the teacher and to take the deaf learners into account, subtitles have already been added to the animation on the greenhouse effect; a recommendation will be to do the same for the DVD-'Planet Earth, a Living Heritage'.

7.4.2 Inform training workshops

The research showed that teachers were empowered to effectively facilitate learning about climate change and renewable energy. It also showed that the intention for teacher professional development was to support teachers to take the learning material into practical use. It was found that Cases A, B and E showed expertise in their pedagogical use of the learning material.

The workshops for the teachers are important, because most respondents over the years have indicated that it was the first training that they had received on renewable energy. The results showed that teachers don't need more training on renewable energy, the workshops are sufficient in developing their understanding of renewable energy, but it is recommended that they are guided more on how to include and use the learning material in their lessons.

A recommendation will be that the teacher professional development workshops need to be redesigned to give teachers an opportunity to engage more with the material during the training session and to collaborate with other teachers on how they will incorporate and present the material in their lessons. Therefore the time frame of the workshop will have to be reconsidered.

7.4.3 Network development

The implementation strategy of the renewable energy learning material has changed and been expanded over the years, with positive outcomes. This study showed that a new strategy will have to be developed to include the implementation of the material with Life Science teachers as well.

Seen in the light of success of the renewable energy IPP programme and the importance of renewable energy becoming mainstream not only in South Africa but also in other parts of the world, an implementation strategy to roll-out nationally should be considered and developed. A recommendation will also be to develop more networks with different IPP's. It is of great importance that teachers and learners receive more information in this regard.

7.4.4 Funding

The availability of funds throughout the years had a big influence on the material development, roll-out and implementing strategy, as well as hosting the workshops. This can be attributed to the fact that there is still a large group, especially of decision makers, who don't believe or understand the necessity of providing learners with knowledge on renewable energy, essentially showing a lack of understanding of the urgency and importance of ESD in the curriculum.

For the continuity of the programme, it is of utmost importance to secure enough funding for a designated time to disseminate and implement the material nationally.

7.5 Value Created for Teachers in Their Teaching and Learning Practices

One aspect of value that was created by the materials was that teachers' and learners' understanding and conceptual knowledge of renewable energy resources, climate change and how to reduce negative environmental impacts increased. This empowered them to make informed choices and decisions in terms of their energy lifestyle and energy use.

Teachers also expressed an appreciation of the resources, having found it of value, as it is a comprehensive resource on renewable energy and can be used as a reference, noting that the textbooks do not provide enough information on these topics. The materials thus saved teachers preparation time and improved the quality of knowledge communicated to learners. Learners also enjoyed the new ideas and learning challenges associated with the material.

For learners the value was that they could relate to the context because it is a South African product; the materials also showed the local developments in the renewable energy industry in the country and that gave them hope. They could also identify possible job opportunities and

further research possibilities in the renewable energy field which excited them and they were required to think about what their contribution could be towards a more sustainable future of energy use.

Two aspects that really stood out, in terms of value added for the teachers and the learners, were the extensive use of visual images and the incorporated e-learning strategy. The images were of significant value, especially for the deaf learners, because the images made it possible for them to construct conceptual knowledge on the use of renewable energy and to see how the technologies work.

The e-learning strategy incorporated in the Geography assignments required learners to use their mobile phones to do research; it was a natural extension of the technological environment in which they continually operate.

It is thus clear that the materials added value for teachers in their teaching practices as well as in learners' understanding of renewable energy. Value was also added to the programme going forward through understanding how the teachers are using the material, what they found valuable, and what could be added to increase the value.

7.6 Recommendation for Further Research

Concerning this study, classroom observation would have provided more in-depth analysis on the exact flow on how the learning material was able to scaffold learning in the classroom in the learning task sequences examined, and what the detailed aspects are that are necessary for ESD. To really be able to probe learning and determine the level at which ESD is taking place, class visits are of utmost importance.

Therefore, for future research, it is recommended to observe how the learning material is used in order to get a more refined grasp of the learning associated with the materials in use, as one will then be able to determine to what extent the learning processes are developing as education for sustainable development processes supporting change. It is unfortunate that there was not a case covering the Physical Science learning activities developed for the learning material. For future research, the study scope can be expanded by including more participants in other subjects as well.

7.6.1 Critical review of the research process

This study was extremely helpful in my own understanding of the learning material, not only in terms of how they came to be used in curriculum settings but also on future material development and a roll-out strategy to support education for sustainable development.

Using the Anne Edwards Learning Task Sequence framework to read the patterns of use of the learning material proved to be very helpful as it gave me a broad sense and understanding of how the material was being used by teachers to support learning and what learning is needed for ESD. To develop learning activities for ESD, one will have to look deeper into how the curriculum accommodates a greater concern for learner-led change; for example, is there time available in the curriculum schedule?

Gathering my data proved to be a challenge, because renewable energy is presented in the third and fourth terms therefore making it very challenging to gather data at a time when the year is being concluded and examinations are a key focus in schools. I had to ask teachers to use the material in the second term. This change was not ideal for two of the three teachers who accommodated me. It would have been helpful and much more enriching if I could have started to gather my data in the third and fourth term of 2015. I would have been better able to address gaps in my data-gathering process. This would have made classroom visits possible and would have provided more in-depth analysis on the exact flow on how the use of the materials in various subjects facilitates learning and extends to the application of new knowledge in ways that might steer change to future sustainability. The current study established a platform for this work to be undertaken in future studies.

7.7 Conclusion

This research informed us how ESD can be engaged in South Africa using a CAPS approach where the learners become much more involved in using the knowledge and thinking about future sustainability. The Anne Edwards Learning Task Sequencing framework was the enabler to show how the current task sequences might be strengthened to enhance ESD and to explore future sustainability energy scenarios for South Africa. In addition, there is some encouraging evidence that the materials are supporting learners to understand their own actions and to deliberate the future in terms of their energy lifestyle choices.

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Appendices

Appendix A: E-mail sent out on: Wed 2015/12/02 13:46

Dear Sir/Madam

Hope to find you well.

Renewable Energy Resource from Stellenbosch University

You have received a set of Renewable Energy learning materials during a workshop we had in 2014. I would like to know whether you have used the set of materials during the year.

Please reply to this email and answer the following 3 questions:

1. Have you used the material? Yes/No
2. For which grade have you used it?
3. In what subject did you use it?

I am currently busy doing research on how teachers use the Renewable Energy resource and would like to know whether you will be interested to participate in the research? Yes/No

Thank you very much for your time, enjoy the well-deserved holiday.

Kind regards

Therese Lambrechts
CRSES schools' project

Appendix B: Summary on the follow-up survey at the end 2015

Survey done in November/December 2015

- Did you use the learning material?
- In which subject?
- For which grade?
- Are you interested to take part in the research?

	No	**Yes**	**Grade**
Techers who used the material	1	50	
In which subjects:			
• Geography		12	11
• Natural Science		29	7-9
• Life Science		4	10-11
• Technology		2	7-9
• Mathematics		1	8
Teachers who showed interest to take part in the research		10	

Appendix C: Teacher questionnaire which informed the contextual profile of the study

Questionnaire on Renewable Energy Teaching Material

Thank you for your involvement in the **Renewable Energy Schools' Project** of the Centre for Renewable and Sustainable Energy Studies (CRSES).

- We value your feedback aimed to inform the proposed updating of the materials
- Please be so kind as to complete the following questionnaire in electronic format, returning it no later than 29 February 2016.
- Your electronic response can be submitted to therese@sun.ac.za
- All information submitted will be confidential and will only be used for research purposes.
- Participation in this survey is voluntary and individuals may withdraw at any time.

PLEASE COMPLETE THE FOLLOWING BY MARKING THE APPROPRIATE BOX(ES) WITH AN 'X'

1. **When and where did you recieve the Renewable Energy (RE) material?**

When	Province	School

2. **Describe your school context by completing the following**

Class sizes	
Equipment available	
Resourced school	
Under resourced school	
Socio economic context	

Please make any other remarks about your school context which can be of value to the RE material.

3. **With which grades have you used the following components of the RE teaching material?**

	Grade 8	Grade 9	Grade 10	Grade 11	Grade 12
Watched the DVD					
Presented all of the teaching materials to learners					
Printed out Word document to give to learners as a booklet					
Used Power Point presentations					
Employed teacher's manual					
Did assignment on energy consumption with learners					
Used the posters in the classroom					
Made use of the glossary					

What value was added by using the above activity/ies?

4. **How did most of the learners fare when they completed the assignment on energy consumption?**

Good	Average	Poor

Please explain your answer.

5. **How did learners respond to the DVD: "Planet Earth, A Living Heritage"?**

	Positive	Negative
Everybody		
The majority		
Some		
None		

Was looking at the video valuable? Why?

6. **Which of the topics from the RE material have you used?**

	Used	Subject/grade
Greenhouse effect		
Climate change		
Renewable energy		
Non-renewable energy		
Generation of electricity		
Solar energy		
Wind energy		
Hydro energy		
Geothermal and ocean energy		
Biomass energy		
Energy efficiency		

Why did you choose these topics?

7. **Did the manual, DVD and CD meet your needs?**

	Yes	No
Manual clear and easy to follow		
Content in logical sequence		
Content covers the most important aspects of the subject		
Supplies too much complex information		
Teaching material compiled in such a way that it provides for the differing abilities of learners:		
Faster learner		
Slow learner		
Privileged learner		
Disadvantaged learner		
Information on the flash drive is clear and easy to follow		
Had trouble playing the DVD		
Posters adds value to the different subjects		
The learner material meets CAPS requirements		

What aspects of teaching the topic does the RE material not take into consideration?

8. **Experience in Renewble Energy**

Please complete

Did you have any previous experience or receive training on Renewable Energy before the workshop?
Need more training to present the materials?

9. **Do you have any other valuable infomation on the RE material which was not covered in the above questions?**

THANK YOU FOR YOUR KIND COOPERATION

Appendix D: The Edwards Learning Task Sequencing

<table>
<tr><td colspan="4">Knowledge is displayed</td></tr>
<tr><td colspan="2">Quadrant 4
Students display their understanding and knowledge through summative assessment</td><td colspan="2">Quadrant 1
Knowledge is displayed by the teacher or more expert learners as they model and instruct key concepts.</td></tr>
<tr><td>• What are the learners doing?
Complete the summative assessment task
• Master the tool of uncertainty.</td><td>What are the Teachers / Expert learners doing?
• Summative assessment of learning
• Give grades for the display of new found understandings.
• Jumping point for new cycle.</td><td>What are the learners doing?
• Learners engage through meaning making.
• Respond to teacher's questions</td><td>What are the Teachers / Expert learners doing?
• Introduction of key concepts and revisiting what is already known.
• Help learner recognise a gap in their knowledge that can be filled.
• Imitation(Vygotsky)
• Demonstrate knowledge
• Diagnose the interpretation by the learners
• Introduce the learners in using the language and other forms of the knowledge displayed
• Courteous conversation that leads learners towards mastery of the knowledge that matters in a subject.</td></tr>
<tr><td colspan="2">Quadrant 3
More open tasks which enable learners to apply key concepts and ways of enquiring. Task may be phrased as an open-ended question for learners to research</td><td colspan="2">Quadrant 2
Tightly structured tasks which demand engagement with key concepts (substantive knowledge) and ways of enquiring (syntactic knowledge)</td></tr>
<tr><td>What are the learners doing?
• Open-ended, problem solving activities.
• They take control of the knowledge they have just grasped and use it to solve problems.
• Students show agency</td><td>What are the Teachers / Expert learners doing?
• Require high levels of teacher subject knowledge.
• Knowledgeable resources responding to students questions. Only intervening if learners are experiencing real difficulty.</td><td>What are the learners doing?
• Students show thinking skills and respond to the task demands, taking control and exploring what they can do.
• Students scope the tasks, allocate time, and identify needed resources.
• Students self-assess against criteria – referring to knowledge and strategies used.</td><td>What are the Teachers / Expert learners doing?
• Teacher's formative assessment of Q1 indicates that learners are starting to make the connections between already known and new knowledge.
• Individual, paired or grouped tasks are given.
• Teacher giving actively formative feedback on both the use of knowledge and the organization of learning.</td></tr>
<tr><td colspan="4">ZPD takes place in quadrant 2 and quadrant 3. Semiotic mediation takes place by the use of different mediation tools, for example language or readings. Safe places, mistakes can be made, misunderstandings revealed and risks taken. Acquire and use, internalise and externalise, substantive and syntactic knowledge acquired and used. Learners develop higher order thinking skills and taking control of their own learning through tasks given by the teacher.</td></tr>
</table>

Appendix E: Letter of Consent

Centre for Renewable and Sustainable Energy Studies
K404 Knowledge Centre

Mechanical Engineering

Stellenbosch University
Stellenbosch
7600

17 February 2016

Dear Teacher

I am a registered for a Masters in Environmental Education student at Rhodes University and am conducting research into the Renewable Energy (RE) material you received in a training workshop during 2013-2015. My research is centred on how teachers are working with the RE materials in their lessons and the research will be used to update and improve the materials so that they are more relevant to teachers' needs. Please note that for the research, all information used is coded and will not be traceable or identified as coming from individual teachers or their schools. In order to protect your identity and maintain anonymity and privacy, no real names will be used in the writing up of the thesis.

Agreement to participate in the research will involve the following:

1. Completing a survey questionnaire:
   Each participating teacher will receive a questionnaire in the form of a survey to be completed and sent back to me
2. Those agreeing to participate further will provide follow-up documents:
   (I will ask teachers who are willing to participate in a second phase of the study to submit the following documents accompanied by a short description of the learning sequence you followed.)
   Documents to be submitted:
   - Lesson plan
   - Assessment tool
   - Evidence of work done by learners
3. Follow-up interview:
   If I have any further questions on the above or want to clarify data received, I will send emails to individuals.
4. Value creation questionnaire
   If I need more information on the value that was created by making use of the RE material another questionnaire will be sent out.

There will be no classroom visits associated with the study as my research interest is how teachers are using the materials and how the materials can be improved to make them more relevant.

Research Ethics: Confidentiality and the right to privacy, dignity, and honesty will be maintained, no names or email contact details will be revealed. Participation in this study is completely voluntary. Even if you agree at this time to participate, you are free to withdraw from the study at any time without obligation to the researcher, the Rhodes University or Stellenbosch University.

This consent letter, and analysis results will be kept safe and confidential. All the data and documents used during the conduct of the study will be disposed of a few years after the thesis of the researcher is finalised.

Participation in the proposed study of teacher use of the Renewable Energy Materials.

If you are willing to participate, please sign in the appropriate boxes:

	Yes	No
1. For my documents to be to be used to inform the study		
2. To participate in follow-up interviews via emails for the research		
3. To complete two questionnaires for the research		

I herewith give my consent that I am willing to participate in this study. Please tick box below.

☐

Date_____

Your positive regard on this matter is highly appreciated.

Yours truly,

Therese Lambrechts

Schools' Project

Centre for Renewable and Sustainable Energy Studies, Stellenbosch University

therese@sun.ac.za

Cell: 0732650855

Should you wish to know more about the study, please feel free to contact my supervisor:

Prof Rob O'Donoghue

Director, Environmental Learning Research Centre (ELRC)

Faculty of Education
Rhodes University
Cell: 083 2121 670

r.odonoghue@ru.ac.za

Appendix F: Feedback on Questionnaire

Refereced as: Questionnaire (Q)

Questionnaire on Renewable Energy Teaching Material

Thank you for your involvement in the **Renewable Energy Schools' Project** of the Centre for Renewable and Sustainable Energy Studies (CRSES).

- We value your feedback aimed to inform the proposed updating of the materials
- Please be so kind as to complete the following questionnaire in electronic format
- Your electronic response can be submitted to therese@sun.ac.za
- All information submitted will be confidential and will only be used for research purposes
- Participation in this survey is voluntary and individuals may withdraw at any time.

The answers to questions 1 and 2 is incorporated in the depth case studies.

PLEASE COMPLETE THE FOLLOWING BY MARKING THE APPROPRIATE BOX(ES) WITH AN 'X'

1.When and where did you recieve the Renewable Energy (RE) material?

When	Province	School

2. Describe your school context by completing the following

Class sizes	
Equipment available	
Resourced school	
Under resourced school	
Socio economic context	

Please make any other remarks about your school context which can be of value to the RE material.

3: The materials used across the grades in each case

The table shows the various components of the material that has been used for different grades.

	Grade 8	Grade 9	Grade 10	Grade 11	Grade 12
Watched the DVD	A, C	A, D, E	A	A, B	
Presented all of the teaching materials to learners	C	A, D, E		B, F	
Printed out Word document to give to learners as a booklet		D, E, G		B, F	
Used PowerPoint presentations	A	A, D, E, G	A	A, B, F	A
Employed teacher's manual	A, C	A, D, E	A	A, B, F	A
Did assignment on energy consumption with learners	A, C	A, D, E		B, F	
Used the posters in the classroom	A, C	A, D, E	A	A, B, F	A
Made use of glossary	A, C	A, D, E	A	A, B	A

The teachers were asked what value was added by using the different components of the material.

Content

Case A mentioned that the "textbooks are not comprehensive enough and to teach the section well one does need extra information and the resources supplied that" (CAQ, L51-52).

DVD: Planet Earth, a living Heritage

Case E commented that the learners "enjoyed the video material and understood it to a large extent as [she] tried to explain the content by pausing the video" (CEQ, L46-52).

Image based PowerPoint presentations

Case B also added that "it is a South African product with local pictures and examples" CBQ, L39).

Case E added that "the students had the opportunity to see the solar power, hydro-electric power and wind power pictures on the power point presentations. This gave them the opportunity to picture the process of alternative energy sources in a practical way. Deaf learners often lack knowledge of the world and do not learn many things incidentally through communication with others or through overhearing significant others talking (CEQ, L46-52)."

Case G mentioned that the learners "also enjoyed the PowerPoint presentations, because the pictures aided the scaffolding process" (CGQ, L40-43).

Lesson assignments

Case B commented that "the lesson assignments are written in a way that learner involvement and group work was implemented very well. It gave us hope and made us proud" (CBQ, L37-40).

Posters

Case A stated that they "had two sets of [the] posters laminated straight after the presentation of [the] course in 2014. One set is put up in the Physical Sciences passage and the other in the Life Sciences passage. Enjoyed by all our students every day and parents during our open day" (CAAL, L3-5).

Conceptual knowledge

Case C said that by using the different components value was added to "their understanding of solar energy" (CCQ, L42).

Case D said that the "learners were able to fully grasp the concepts and even explain their application to everyday life" (CDQ, L21-23).

Case F stated that the different components were "good to get students to think about energy" (CFQ, L34).

Case G mentioned that "the learners enjoyed the Word document as the textbook is very vague on the topic of renewable energy" (CGQ, L40-43).

4. How learners fared when completing the assignment on energy consumption

The table below indicates which teachers used the energy consumption assignment and how learners fared in completing it.

Good	Average	Poor
A, F, D, E	B	C

The teachers were asked to explain their answers.

Case A said that they "made use of the practical assignment on slide 12 of the Electricity section with [their] grade 9 Natural Science (Energy and Change)". She said that it "is a lovely CASS activity. [They] also added a cost analysis by adding an extra column to the table" (CAAL, L6-8).

Case B mentioned that a "lot of hostel learners did not really take part and had easy excuses. It was more of a motivational problem than a real material problem. [But it resulted as] an eye opener to a lot of them" (CBQ, L53-55).

5. Learners response to the DVD "Planet Earth, a Living Heritage"

The table below shows whether teachers have watched the DVD: 'Planet Earth, a Living Heritage' and how learners responded by watching it.

	Positive	Negative
Everybody	B, D	
The majority	C, E, F	
Some		C
None		

The teachers were asked whether it was valuable to watch the DVD and they also had to explain why it was valuable.

Case B said that "yes" it was valuable, because it is of "very high quality, with very recent statistics and a lot of seen and unseen South African places. The learners are used to visual stimulation and this helped a lot" (CBQ, L67-68).

Case C also said "yes [it was valuable], it broadened [the learners] horizons" (CCQ, L67).

Case D mentioned that "it created a personal impact on the learners on the issues affecting the environment" (CDQ, L30-31).

Case E mentioned that "it was inspiring and valuable, [but] unfortunately it did not accommodate deaf learners by having subtitles" (CEQ, L67-68).

Case F said "yes" it was valuable, because of the "good visuals [and] interesting facts [and it is] relevant" (CFQ, L62-65).

6. Overview of the topics used

Table 5.4 below shows which topics were used by which case for which grade.

	Used by Case	Subject/grade
Greenhouse effect	A, B,D, F	Geography grade 11, Life Science grade 10, 11 & 12, Natural Science grade 8 & 9
Climate change	A, B, D	Geography grade 11, Natural Science grade 9

Renewable energy	A, B, D, F	Geography grade 11, Life Science grade 11 & 12, Natural Science grade 8 & 9
Non-renewable energy	A, B, D	Geography grade 11 Life Science grade 11 & 12, Natural Science grade 8 & 9
Generation of electricity	A, B, D, G	Geography grade 11, Natural Science grade 9
Solar energy	A, D, C, F, G	Geography grade 11, Natural Science grade 9 Mathematics grade 8
Wind energy	A, B,D, G, E	Geography grade 11, Natural Science grade 9
Hydro energy	A, D, G, E	Natural Science grade 9 Life Science grade 11 & 12
Geothermal and ocean energy	A, D, G	Natural Science grade 9
Biomass energy	A, D, G	Natural Science grade 9 Life Science grade 11
Energy efficiency	A, D, E	Natural Science grade 8 & 9

The teachers were asked why they chose these topics. The first reason was the link with CAPS:

Case A mentioned that "all these topics come up in the Natural Sciences and the Life Sciences syllabi" (CAQ, L94)

Case B used the material for Geography and he mentioned that the "material fit well into the syllabus under Research" (CBQ, L80-83).

Case D used it in Natural Science because "most of the topics link with the curriculum" (CDQ, L34-36).

Case E explained why she only used certain topics and others not. She said that "the CAPS document does not really focus a lot on geothermal energy, biomass energy and ocean energy. [She] will leave out the extensive details when mentioning these topics because they are not really a great feature in [the] South African context. Learners can be told what these topics are, but there is quite a large quantity of content knowledge in the other types of renewable and non-renewable energy that is current and growing in popularity in our country. In [her] opinion, these aspects should more be the focus of [the] lessons" (CEQ, L74-79).

Case G chose the topics in Natural Science because she "had to consider CAPS, and renewable energy was the topic of my last lesson" (CGQ, L71-72).

The other reason given was applicability:

Case B said he chose "wind energy because [they] had [a]sports meeting in Vredenburg so [they] passed a wind farm. [He] also did [the] assignment on Koeberg because of Thys Point Nuclear plans being in the news" (CBQ, L80-83).

Case C mentioned that they "have two solar farms just outside town" (CCQ, L78).

Case D said that "the aim was also to create awareness in the learners on issues affecting the environment" (CDQ, L34-36).

Case F mentioned that the reason why he chose these topics was because of "personal interest and [that he was] rushed for time" (CFQ, L79).

7. Did the manual, DVD and CD meet your needs?

The table below shows whether the material met certain criteria.

	Yes	No
Manual clear and easy to follow	A, B, C, D, E, F, G	
Content in logical sequence	A, B, C, D, E, F, G	
Content covers the most important aspects of the subject	A, B, C, D, E, F, G	
Supplies too much complex information	C, E, G	A, B, D
Teaching material is compiled in such a way that it provides for the differing abilities of learners:		
Faster learner	A, B,C, E, F, G	
Slow learner	A, B, D, F, G	C, E
Privileged learner	A, B, C, E, F, G	
Disadvantaged learner	B, C, E, F, G	
Information on the flash drive is clear and easy to follow	A, B, C, D, E, G	
Had trouble playing the DVD	B:	B, C, D, E
Posters add value to the different subjects	A, B, C, D, E, F,	
The learner material meets CAPS requirements	B, C, D, E, F, G	

On the question of what aspects of teaching the topics does the RE learning material not take into consideration?

1. **More information needed**

Case A mentioned that "more detailed explanations are needed for [the] topics enhanced greenhouse effect, and ozone. It would be good if suggestions for research topics are given after each section. The DVD on the Centre for Renewable and Sustainable Energy Studies is very good in motivating learners to attempt research and enter the Eskom Science Expo under the category 'renewable energy'" (L107-111).

2 **Teaching for different grades**

Case B mentioned that the material does not take into consideration "how to use [it] on different levels (grades). [An] unexperienced teacher tried to use the material, as is, with juniors (Grade 8's). [The teacher] struggled" (CBQ, L 97-98).

Case E said that the materials do not take into account "the time limitations in the 3rd term for teaching the module on Energy and Change. There is too much information for the Senior Phase in Natural Sciences, although not too much for FET Physics. Natural Sciences teachers are required to teach about Forces, Safety with Electricity, Energy Generation, Renewable and Non-Renewable Energy Generation and Saving on the Cost of Electricity (including the Greenhouse Effect). It will not be possible to teach all the aspects in the detail that it appears in the manual or on the CD, although some of the diagrams are interesting for enrichment purposes (CEQ, L91-97)".

Case G added to the above by mentioning that "some of the content was too sophisticated [for] Grade 9 level, to squeeze into the time set aside by CAPS for the topic of renewable energy" (CGQ, L80-81).

3. **Mathematics**

Case C: said that the "incorporation with Mathematics needs attention (CCQ, L90)".

4. **Nuclear energy**

Case D mentioned that "the RE material does not give much detail on the impacts of nuclear energy" (CDQ, L39-40).

5. **Time**

Case F mentioned that he "will still be using it, [but] the school is so rushed and [they] do not have time to use it all [at that point]". He also added that he has a "tight syllabus to complete" (CFQ, L86-88).

6. PDF's

Case G mentioned that "if [she] could change something about the PowerPoint presentations it would be to not have them as PDF's. She further explained that her "mentor teacher did not have Adobe, so [she] was disappointed when [she] could not use the slides when [she] wanted to use them)" (CGQ, L77-85).

8 Please complete the following:

In the table below teachers had to describe whether they had ever received training on renewable energy before, and whether they need more training currently

Did you have any previous experience or receive training on Renewable Energy before the workshop?
Case A mentioned that she has "been teaching aspects of it for 20 years. As an Eco-school we do investigate related issues" (CAQ, L119). Case B mentioned that "only as part of normal Geography learning material" (CBQ, L 106). Case C answered "no" (CCQ, L97) Case D said "yes, in 2015 [he had the] similar workshop" (CDQ, L42) Case E said "yes [she had the workshop] in 2013" (CEQ, L103) Case F answered "no" (CFQ, L101) Case G answered "no" (CGQ, L89)
Do you need more training to present the materials?
Case A mentioned "no" (CAQ, L119) Case B mentioned that the "workshop was more than enough but every bit of training/ consulting/ networking makes a difference" (CBQ, L106). Case C stated "yes" he would like more training to present the workshop (CCQ, L97). Case D stated "no" he does not need more training (CDQ, L42). Case E said "no" (CEQ, L103) Case F answered "no" (CFQ, L101) Case G answered "yes. As [she] wasn't involved in designing the materials, and has very little experience as a teacher, [she felt she] can definitely improve on [her] planning and presenting of the lesson" (CGQ, L89).

The teachers were asked whether they had any other valuable feedback which they could add which was not covered in the above mentioned questions.

The following were suggestions received from the teachers.

Subject advisors:

Case A suggested that "the subject advisors [should be made] aware of [the] material, this will ensure integration with the curriculum" (CAQ, L125-126).

Positive attitude

Case B mentioned that "schools are supposed to prepare learners to become independent members of the community that can play an uplifting role. 'What is my role that I can play' as [a] learner was [also] identified [and the] positive attitude of the material is very valuable" (CBQ, L111-115).

E-learning

Case B added that "ways to integrate [the material] with an e-learning strategy [was] identified" (CBQ, L111-115).

Potential job opportunities

He also said that a "very wide range of potential job opportunities [was] identified in [the] material" (CBQ, L111-115).

Separate resources for different subjects

Case E suggested that "perhaps in the future, a separate resource could be created for Natural Science teachers with less detail, but still having the appropriate diagrams of the latest technology in Renewable Energy" (CEQ, L107-109).

Visits

Case F mentioned that "a visit to [the renewable energy] centre would be great" (CFQ, L107).

Nuclear

Case D stated that "more information is needed on the uses and environmental impacts of using nuclear energy as it is becoming a burning issue" (CDQ, L45-47).

Appendix G: Data analysis from Case A

Document Case A (CA) Questionnaire (Q) (CAQ)	Code Line (L)	Quadrant			Code Line (L)
Activity	**CAQ**		**Learning Task Sequence**	**Value added**	**CAQ**
All the available components of the materials were used for Natural Science grade 8 & 9 and for Life Science grade 10-12. Presented all of the materials to learners. Used PowerPoint presentations. Employed teacher's manual. Used the posters. Made use of the glossary. Used energy audit assignment.	CAQ, L48	1 2	Overall orientation and key concepts were displayed by the teacher through the use of different mediation tools – DVD, PowerPoint presentations, Posters and Glossary. Did not print the booklet for the learners (Eco –School) as they understand sustainability	"Textbooks are not comprehensive enough and to teach the section well; one does need extra information and the resources supplied that".	CAQ, L51-52
The assignment on energy consumption was completed on a good level. The "practical assignment on slide 12 of the Electricity section" was completed with her grade 9 Natural Science learners (Physical Sciences section	CAQ, L63 CAAL, L6-7	2	Learners engage with concepts through an activity on energy use.		
She added that "this is a lovely CASS (Continuous Assessment) activity. In this case a cost analysis was added in "an extra column to the table".	CAAL, L7-8	4	The teacher used the energy audit assignment as a CASS activity and graded learners on it and therefore it became a summative assessment.		
Unfortunately they could not find the DVD 'Planet Earth, a living Heritage'	CAQ, L78	1		Learners are very attentive when watching videos. One could make a asssessment activity out of it, by asking questions regarding the video after they have watched it to reinforce the knowledge and to test their listening skills.	CAQ, L80-82
Topics used were: Greenhouse effect Climate change Renewable energy Non-renewable energy Generation of electricity Solar, Hydro, Wind, Biomass, Ocean and Geothermal	CAQ, L90 CAQ, L94	1 2 3	The reason for choosing these topics are because all these topics come up in the Natural Sciences and the Life Sciences syllabi	Valuable information added by the teacher was: More detailed explanations are needed for Enhanced Greenhouse effect and Ozone. It would be good if suggestions for research	CAQ, L107-111

Energy and energy efficiency				topics are given after each section. The DVD on the Centre for Renewable and Sustainable Energy Studies's website is very good in motivating learners to attempt research and enter the Eskom Science Expo under the category "renewable energy	
				She also suggested that the subject advisors should be made aware of the material, this will ensure integration with the curriculum.	CAQ, L125-126
Document Case A Account of Lessons (CAAL)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CAAL**		**Learning Task Sequence**	**Value added**	**CAAL**
Posters put up in two passageways in school	L3	1	Introduction of new knowledge. Concepts are revisited by students passing the posters daily.	Enjoyed by all our students every day and parents during our open day	CAAL, L5
Used practical assignment (energy audit) for grade 9 Natural Science (NS)	L6	2	Learner engagement with new concepts.		
Teacher added a column on cost analysis used for CASS activity	L7	4	Summative assessment	This is a lovely CASS activity.	CAAL, L6-7
Differences between RE and Non-RE. Explanation of the greenhouse effect for grade 8 & 9 NS and LS grade 11 & 12	L9-11	1	Learners are introduced to new knowledge and concepts are explained		
Use information on Hydro-energy in section of Human Impact in LS grade 11 & 12	L12-L18	1	Introduction of new knowledge to learners	"Very useful for educators when teaching Human Impact in grade 11 Life Sciences"	CAAL, L14-15
Biomass is also covered in this (Human Impact) section as well as in the chapter on respiration in grade 11 Life Sciences.	CAAL, L15-16	1	Revisiting of concepts by making connections for learners with existing projects	The students enjoy the section on Biomass energy - we have a rural school in Chintsa East who makes use of biofuel to cook their lunch. An inspiration to our kids.	CAAL, L16-18

		3	Learners can use examples to show agency in their research projects	My grade 11 students who are interested in studying Engineering really enjoyed your inspiring DVD on your website.	CAAL, L19-20
"Motivate children to use renewable energy as topic for their Eskom Science EXPO"	L21-L23	3	Motivate learners to show agency.		
Teachers ask for research ideas in renewable energy	L29	3	Teachers understand sustainability and that learners need to take agency of new found knowledge		
Document Case A Interview 1 (CAI1)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CAI1**		**Learning Task Sequence**	**Value added**	**CAI1**
Educators can make use of the material when we cover "Life on Earth" in the grade 10 Life Sciences curriculum. We teach the causes of the five past mass extinctions in detail and then discuss the 6th one caused by mankind. The question is then asked: what can we do to prevent this speedy 6th extinction? The use of renewable energy can then be used as one of the solutions.	CAI, L3-7				
Document Case A Learners Work (CALW)	**Code Line (L)**	**Quadrant**		**Document Case A Interview 2 (CAI2)**	**Code Line (L)**
Activity	**CALW**		**Learning Task Sequence**	**Value added**	**CAI2**
GRADE 9 RENEWABLE ENERGY SOURCES RESEARCH PROJECT TERM 3 2016 DUE DATE: Monday 15 August 2016 South Africa's energy landscape is dominated by electricity from coal. However, there are a number of renewable energy options available for South Africa, for example: wind energy, hydropower, solar energy, solar photovoltaic, solar water heating, biomass	CALW, L1-6	3	Learners had to apply new knowledge and show agency through the research project.	In general I am disappointed in how some of the learners just 'copied and pasted' information from the internet. Also they did not find good information on how many renewable energy plants have already been built in South Africa. It seems that they have struggled to find information on what is available.	CAI2, L6-10

energy, landfill gas, ocean current energy and ocean wave energy.					
INSTRUCTIONS Research FOUR types of renewable energy under the following headings: • Explain how each type of renewable energy generates electricity. • List the advantages and disadvantages of each type. • Discuss the availability of each type of resource in South Africa. • Evaluate how much of each energy source is already being used in South Africa.	CALW, L8-12	3		I think the days of giving projects which learners have to do research on has passed, too many of them are helped by their parents or they copy it directly from the internet. We will have to focus on Hypothesis Testing / Scientific Research. Where the child goes out and asks questions and does interviews or send out emails to determine the results.	CAI2, L12-15

Appendix H: Data analysis from Case B

Document Case B (CB) Questionnaire (Q) (CBQ))	Code Line (L)	Quadrant			Code Line (L)
Activity	**CBQ**		**Learning Task Sequence**	**Value added**	**CBQ**
All the available components of the materials were used for the Geography grade 11 class. Watched DVD. Presented all of the materials to learners. Printed Word document, gave to learners as a booklet. Used PowerPoints Employed teacher's manual Used the posters Made use of the glossary Used assignments.	CBQ, L33 CBQ, L37-38	1 2 3 4	Overall orientation and key concepts were displayed by the teacher through the use of different mediation tools – DVD, PowerPoint presentations, Printed Booklet, Posters and Glossary. Learners engaged with the concept through the assignments which "are written in a way that learner involvement and group work was implemented very well". The assignments were graded and the results were used for summative assessment.	"It is a South African product with local pictures and examples It gave us hope and made us proud".	CBQ, L39-40
The assignment on energy consumption was completed on an average level. "A lot of hostel learners did not really take part and had easy excuses. It was more of a motivational problem than a real material problem".	CBQ, L49-54	2	Learners engage with concepts through an activity on energy use.	The enquiry resulted in "an eye opener for a lot of them".	CBQ, L55
All the learners responded positively on the DVD: 'Planet Earth, a living Heritage'.	CBQ, L63	1	New knowledge and key concepts were displayed by the DVD. Learners engaged by watching the DVD	Watching the DVD was found valuable, because it is of a "very high quality, with very recent statistics and a lot of seen and unseen South African places. The learners are used to visual stimulation and this helped a lot".	CBQ, L67-68
Topics used were: Greenhouse effect Climate change Renewable energy Non-renewable energy Generation of electricity Wind energy	CBQ, L76	1 2 3	The reason why the teacher introduced and discussed the key concepts in these topics was because, for the "time available, we will do the rest later. Wind energy because [they] had [a] sports meeting in Vredenburg so [they] passed a wind farm. Also did assignment on Koeberg because of Thys Point Nuclear plans being in the news. This material fit well into the syllabus under research" (CBQ, L80-83).		

				The teachers added the following valuable information on the RE material which was not covered in the questionnaire: "Schools are supposed to prepare learners to become independent members of the community that can play an uplifting role". Therefore the "positive attitude of the material [is] very valuable. Ways to integrate with an e-learning strategy identified. Very wide range of potential job opportunities identified in material. What is my role that I can play?".	CBQ, L111-115
Document Case B (CB) Account of Lesson (AL) (CBAL)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CBAL**		**Learning Task Sequence**	**Value added**	**CBAL**
Some sections of the materials were presented at the end of the second term to 2 Geography classes over a period of two weeks; it fitted in the syllabus under research. The rest will be presented later in the year in the chapter on Resources and Energy.	CBAL, L3-4, CBAL, L5-7 CBAL,L 9-14	1 2 3	The teacher presented the material according to the Geography questioning method which is: What is it? Definitions, Concepts. How does it work? Where does it occur? How does it influence people? What can we do about it?		
The teacher used the PowerPoint presentations and video materials to answer the first two questions. 1. What is it? Definitions, Concepts. 2. How does it work?	CBAL, L16-18	1	Background information and introduction to key concepts were provided to learners so that they would be able to handle the work later on.		

The following concepts were discussed: Greenhouse effect Climate change Renewable energy Non-renewable energy Generation of electricity	CBAL, L20-25	1	For the sake of time and to focus on the role of humans, it was not expected of learners to do research on each concept, therefore the focus was to provide the key concepts so that it could become known concepts in discussions and investigations which would follow later on. Some concepts were presented by the teacher and some by learners.		
Learners had to do the energy use assignment at their homes.	CBAL, L26, 29-30	2	Some learners did the assignment and the feedback had very positive results and gave the project momentum.	Measured according to the feedback, this assignment was not very successful, because a number of the learners are in the hostel and they did not even try.	CBAL, L27-28
The second Geography question: (How does it work?) attract more attention, especially from the Physical Science learners.	CBAL, L31-33	1	Physical Science learners explained to the other learners, with the help of a generator from the Science lab, how electricity is generated.		
Not enough time was spend on maps, "I will emphasize it next time more because it is such an integral part of Geography. The question on where does it occur were a little bit neglected. Enough maps are included in the material, but I did not ask enough questions".	CBAL, L34-37	2	Map work, learners engage with concepts.		

Most of the group activity and research was done on the last two questions. (How does it influence people? and What can we do about it?) The question about people involvement was well addressed in the activities.	CBAL, L38-40	3	"One of the biggest challenges for teachers is to be e-relevant in the classroom. This involves more than substituting paperwork with tablets, but the integration of soft-and hardware".	The activity was a great experience in e-learning and a big step forward. The group activity worked better than previously, maybe because of the diversity. A wide variety of skills was addressed in the activity and usually only a few learners take part and the rest are apathetic, which was not the case with these activities. A number of learners used technology as a natural way of learning and the positive South African examples of solutions were a very nice experience in the class.	CBAL, L41-48
Document Case B (CB) Learners Work (LW) (CBLW))	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CBLW**		**Learning Task Sequence**	**Value added**	**CBLW**
As part of the two questions - How does it influence people? and What can we do about it?, The teacher did two research questions provided in the material: the one was on the development of a wind farm close to Port Elizabeth and the other was on the Koeberg Nuclear Power station.	CBLW 1 CBLW2 CBLW3	43	The learners provided work of a high quality and showed agency and understanding of the key concepts, as can be seen in the results of how they were graded. Skills like report writing and critical thinking was developed.	The learners provided work of a high quality and the one remark from the teacher was: "the report addressed pros and cons and that the learner was able to take a stand". Critical thinking was also addressed as can be seen in the following remark: "good way of putting your thoughts together, but what does a report look like, can you hand this in as a proposal for yes/no" (CBLW2)? Another example of critical thinking was encouraged where the teacher stated that a "traffic jam will occur if all try to use the same [escape] route" (CBLW 3)	(CBL W1).

Appendix I: Data analysis from Case C

Document Case C (CC) Lesson Plan (LP) (CCLP))	Code Line (L)	Quadrant			Code Line (L)
Activity	**CCLP**		**Learning Task Sequence**	**Value added**	**CCLP**
Topic: Climate change Theme: Solar energy Content area: Measurement; Data handling; amounts/values, operations and relationships Concepts and skills to reach: At the end of this lesson learners should be able to understand and grasp the following: What renewable and sustainable energy sources are includes? What solar water heating is? Thermal solar power stations are and includes? Photovoltaic panels are and includes? Specifically, what solar energy is and includes?	CCLP, L1 - 10				CCLP
Learners will complete activities regarding to solar energy	CCLP, L11	2			
Learners will go on an educational visit to the Sishen Solar Plant outside Dibeng	CCLP, L12-13	3			
Resources: Introduction to Renewable energy sources- manual Sishen solar Plant Writing board Computer and projector Activities assignments Posters: Solar Energy	CCLP, L 15	1			
Existing knowledge: It is expected that learners have a reasonable knowledge of electricity as well as the drawing of graphs.	CCLP, L20-21				
Revision: none					

Lesson 1 Display poster on solar energy. Watch DVD: Planet Earth, a Living Heritage Discuss the following concepts with the learners: • What is energy? • Renewable and non-renewable energy sources • The world's energy resources • Greenhouse effect • Environmental impact • SA energy use	CCLP, L25-33	1	"It is expected of learners to take part in the discussions. Guide learners with questions like: Can energy be created? Can energy be stored for later use? What do we need energy for? Give examples of renewable and non-renewable energy sources. How does it influence our environment? How does it influence you and your household"? (CCLP,L34-38)		
Lesson 2: Use the PowerPoint presentation on solar energy slide 2 -18. The slides are put up on the board	CCLP, L43-58. CCLP, L59-60	1	Explain to learners what solar energy is and what it includes. (CCLP, L41-42)		
Learners visit the Sishen Solar Plant	CCLP, L62-64	1	Learners are introduced to photovoltaic panels, how a solar farm operates and what the aim of a solar plant is.		
Lesson 3 After the visit the learners complete the following activities:	CCLP, L 65-69	2	Activity 1: Matching descriptions to graphs – group work Activity 2: Interpreting graphs - individual Activity 3: Showing increase and decrease on graphs - individual		
Lesson 4	CCLP, L 72	4	Learners complete activity 4		
Document Case B (CB) Questionnaire (Q) (CBQ)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CBQ**		**Learning Task Sequence**	**Value added**	**CBQ**
Question 1 & 2: The feedback is incorporated in the background information of Case B	CCQ, L 17-27				CCQ, L 27
Question 3: The teacher made use of the following components of the material: • Watched the DVD; • Employed teacher's manual; • Energy use assignment • Used the posters;	CCQ, L 36	1 2	Overall orientation and key concepts were displayed by the teacher through the use of different mediation tools – DVD, Posters and Glossary. Learners engage with the assignments.	Value was added to "their understanding of solar energy".	CCQ,L 42

• Made use of the Glossary.					
Question 4: The assignment on energy consumption was completed on a **poor** level.	CCQ, L 48-50	1	It is not clear which activity was completed.		
Question 5 The majority of the learner's responded **positive**, while other responded **negative** to the DVD.	CCQ, L62	1		"Yes, it broadened their horizons".	CCQ, L67
Question 6: Topics used were: Solar energy	CCQ, L 74	1	The reason why the teacher introduced and discussed the key concepts of solar energy is because, "we have two solar farms just outside town".		
Document Case C (CC) Account of Lesson (AL) (CCAL)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CCAL**		**Learning Task Sequence**	**Value added**	**CCAL**
"The investigation has been done in the weeks before the June exams". "Learners didn't take it seriously, because I explained that it is a research project and won't count for their report".	CCAL, L 2 CCAL, L3-4	3		"Most of the assignments were not completed. Maybe I did not put in enough effort with the investigation. I had to handle certain challenges creatively, for example we couldn't visit the solar farm. I relied on the course materials at my disposal, namely the posters, the CD and the manual. In my opinion, the learners still don't understand solar energy. Although they have a vague idea of what it is and they know solar geysers. Most of the concepts and explanations were totally strange to them".	CCAL, L5, L12
Document Case C (CC) Learners Work (LW) (CCLW)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CCLW**		**Learning Task Sequence**	**Value added**	**CCLW**
Question 1: Write a paragraph of about 40 words on your opinion of solar energy?	CCLP, L 80 CCLW, L14-18		The teacher summarized the learners feedback: • The sun gives us energy • The sun gives us energy to generate electricity.		

			• The government must provide us with solar panels so that we can save electricity • Solar energy is expensive to install. • Deben has enough solar energy to generate electricity from the sun.		
Question 2 Name five things which you can do to make more use of solar energy?	CCLP, L81 CCLW, L 19-27		Most learners wrote the following: • I can make a sun stove. • I can put drinking water in the window to get a bit warmer. I can then drink the water to become a little bit warmer. • I can build in big windows in my house to heat up the room during winter. • I can build a window in the roof to save electricity, the sun will shine in and it will not be necessary to switch on the light. • I can install a solar geyser.		
Question3: Gather data on the temperature in your kitchen over a period of seven days on the same time of the day and draw a line graph with your data. You need to be able to discuss your findings with your classmates.	CCLP, L82 CCLW, L 28-32		The line graph was a failure. The learners haven't worked with line graphs yet. Due to a lack of thermometers they estimated the temperature. To raise or lower the temperature they all said one closes or opens the curtains.		
Question 4: Draw a graph showing the difference between real time and solar time for a period of seven days, at 12:00 daily following the movement of the solar panels on the solar farm.	CCLP, L88 CCLW, L 32		Not one learner completed this question.		
Question 5: Design a poster showing the pros and cons of solar energy. You must be able to explain the poster to your	CCLP, L90 CCAL, L33		Not one learner completed this question.		

classmates.					
Question 6 Put together a glossary with all the solar energy concepts you have learned mastered.	CCLP, L 92 CCAL, L 34-38		The words which they wrote were the following: • Solar energy • Energy sources • Greenhouse • Solar oven • Solar panels • Solar farm • Solar heating • Solar energy	I would have wanted that the learners give better quality of work to you, but unfortunately it was not possible. The average mark was 12 out of 25.	CCAL, L43-44
Document Case C (CC) **Interview 1 (I1)** **(CCI1)**	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Question	**CCI1**		**Answers**	**Value added**	**CCI1**
1. What is the size of your school? 2. Medium of language? 3. Timeframe: how much time did you spend on the materials? 4.I am not sure which activities you used • The energy audit provided in the material? • The three activities which forms part of the Maths material which we gave to you? • The activity which you designed which is in your lesson plan?	CCI, L16 CCI, L17 CCI, L 18 CCI, L19		1.778 learners. 2. Medium of language: Afrikaans and English. 3. Six days were spent on the activities, in between the rest of the work. 4. I used the activities which were in the lesson plan. Some of it came from your manual.		
Document Case C (CC) **Interview 2(I2)** **(CCI2)**	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Question	**CCI2**		**Answers**	**Value added**	**CCI2**
Can you please give me feedback on how I have written up your data? For example how did you use the slides?	**CCI2, L39-41**		What you have done looks correct, I am impressed. The posters are now displayed in my classroom permanently. I showed the slides on my laptop. (I don't have a data projector).		

Appendix J: Data analysis of Case D

Document Case D (CD) Questionnaire (Q) (CDQ))	Code Line (L)	Quadrant			Code Line (L)
Activity	**CDQ**		**Learning Task Sequence**	**Value added**	**CDQ**
Question 1 & 2: Feedback is incorporated in the background information of the Case D analyses	CDQ, L11-12			"Most of the learners in the school have reading difficulties which make it more difficult for them to grasp simple concepts. Repeated explanations delay the progress in the curriculum execution".	CDQ, L15-18
Question 3: All the available components of the materials were used for the Geography grade 11 class. • Watched DVD. • Presented all of the materials to learners. • Printed Word document, gave to learners as a booklet. • Used presentations • Employed teacher's manual • Used the posters • Made use of glossary • Used assignments.	CDQ, L 19	1 2 4	Key concepts were displayed by the teacher through the use of different mediation tools – "DVD, PowerPoints, Printed Booklet, Posters and Glossary.	The value that was added was that "learners were able to fully grasp the concepts and even explain their application to everyday life".	CDQ, L21-23
Question 4: The learners fare "good" in the assignment on energy consumption.	CDQ, L24	2		"Most of the learners got marks above the average mark" in completing the energy assignment".	CDQ, L26-27
Question 5: Everybody responded positively to the DVD	CDQ, L28	1	New knowledge and key concepts were displayed by the DVD. Learners engaged by watching the DVD	Looking at the video "created a personal impact on the learners on the issues affecting the environment".	CDQ, L 30-31

Question 6: The following topics were used • Greenhouse effect • Climate change • Renewable energy • Non-renewable energy • Generation of electricity • Solar energy • Wind energy • Hydro energy • Geothermal and ocean energy • Biomass energy • Energy efficiency	CDQ, L32	1	The reasons why the teacher introduced and discussed the key concepts in these topics were because, "most of the topics link with the curriculum. Also the aim was to create awareness in learners on issues affecting the environment".	"Most of the topics link with the curriculum. Also the aim was to create awareness in the learners on issues affecting the environment".	CDQ, L34-36
Question 9:				The teachers added the following valuable information on the RE material which was not covered in the questionnaire: "More information is needed on the uses and environmental impacts of using nuclear energy as it is becoming a burning issue".	CDQ, L45-47
Document Case C (CD) Lesson Plan (LP) (CDLP)	Code Line (L)	Quadrant			Code Line (L)
Activity	CDLP		Learning Task Sequence	Value added	CDLP
The objective of the lesson was "to give learners an understanding of the use of solar power on a large scale and not only in homes".	CDLP, L 6-7				CDLP

Question for learners: Mention any areas you know of where there is large production of electricity using solar energy. Prepare learners for the visit by stimulating their minds with the following questions and aspects: Ask learners to take along the necessary items that include a pen, booklet, cap, water Show learners the model of the photovoltaic cell that you once showed them in class and they should keep the concept of its use in mind.	CDLP, L 15-17	1	"Recap on the different forms of renewable energy by asking learners to list them down in pairs. Ask learners to exchange papers and mark for each other. Give feedback to the class". 1. What are you expecting to see at the solar power plant? 2. Write down questions related to solar energy that you want clarity on, even from your previous understanding of the working and use of solar energy. Teacher reviews background information on how solar energy can be used to produce electricity in different ways		
After the visit ask the learners to write a report	CDLP, L36-38	3	Write a report on the visit to the solar power plant explaining how electricity is generated on a large scale using solar power, and state any concepts (minimum of 3) that they learnt about".		
Research will require use of several resources (such as the library and the internet)	CDLP, L43-45	3	Students research, illustrate and report on advanced solar energy technologies, e.g. on space satellites. The research must also include the pros and cons of solar energy.		
	CDLP, L51	3	Students will design and create a model or a working solar powered device.		
Students may work in groups or as individuals to develop and process the model.	CDLP, L61-65	1 3	Review and discuss solar energy technologies.		

<u>Choices of projects may include</u> Concentrated solar collector for cooking Model of a solar water heater with heat transferred from collector to water container to an output. A model demonstrating solar thermal electricity (with collector and rotating object representing a turbine) A model of a working PV cell device.	CDLP, L67-74	3			
<u>Evaluation</u> To be done when students complete the solar powered projects and present them to the class. Use a rubric to assess the models	CDLP, L76-79	4			
<u>Further enrichment</u> Invite a solar energy specialist or representative from the department of energy for a class presentation on solar energy.	CDLP, L81-87	1	The presentation must end with a question and answer segment whereby learners are free to ask the presenter questions related to what has been presented to seek clarity, or on any other aspect on solar energy.		
Document Case C (CD) Learners Work (LW) (CDLW)	Code Line (L)	Quadrant			Code Line (L)
Activity	CDLW		Learning Task Sequence	Value added	CDLW
The teacher designed his own energy assignment. It consisted of 6 questions: 1. What is energy? 2. What do you understand by the term renewable energy? 3. And non-renewable energy? 4. What does Eskom mainly use for electricity generation? 5. Name any three forms of renewable energy? 6. Why do you think individuals and companies must use renewable energy?	CDLW1 CDLW2 CDLW3 CDLW4 CDLW5 CDLW6				

Appendix K: Data analysis of Case E

Document Case E (CE) Questionnaire (Q) (CEQ))	Code Line (L)	Quadrant			Code Line (L)
Activity	**CEQ**			**Value added**	**CEQ**
Question 1 & 2: The feedback is incorporated in the background information of Case E	CEQ, L 19-24		The learners of my school are all hard of hearing or profoundly deaf. They vary in their ability to hear sound and in their ability to communicate with spoken language. It is an oral school for deaf children, so learners do not communicate with sign language. All learners communicate by speaking. The classes are small, but the abilities of learners vary. Some learners have other learning disabilities besides their hearing losses. The Dominican Grimley school for the Deaf is a special school, but is one of only two academic high schools for deaf learners in the whole of the Western Cape. Being an academic high school, our learners have to meet all the same requirements in the CAPS documents (for various subjects) as learners from mainstream schools. Our learners write the same matric exam, ANA exams and any other standardized tests as students from mainstream schools. They find it difficult to watch videos without subtitles and depend on visual cues to understand the content of videos and spoken language.		CEQ, L 27-38
Question 3: All the available components of the materials were used for the Natural Science classes • Watched the DVD. • Presented all of the materials to learners. • Printed Word document, gave to learners as a booklet. • Used PowerPoints • Employed teacher's manual • Used the posters • Made use of glossary • Used assignments	CEQ, L 43-44	1	"The students had the opportunity to **see** the solar power, wind power, hydro-electric power and wind power pictures on the PowerPoint presentations. **This gave them the opportunity to picture the process of alternative energy sources in a practical way"**	"Deaf learners often lack knowledge of the world and do not learn many things incidentally through communication with others or through overhearing significant others talking. They enjoyed the video material and understood it to a large extent as I tried to explain the content by pausing the video".	CEQ, L 48-52
Question 4:					
Question 5 The majority of the learners responded **positively** on the DVD: 'Planet Earth a living Heritage'.	CEQ, L 65			It was inspiring and valuable. Unfortunately it did not accommodate deaf learners by having subtitles.	CEQ, L 67-68

Question 6: Topics used were: • Greenhouse effect • Climate change • Renewable energy • Non-renewable energy • Generation of electricity • Solar energy • Hydro energy • Wind energy • Energy efficiency	CEQ, L 74-79		The reason why the teacher left out three topics is because "the CAPS document does not really focus a lot on geothermal energy, biomass energy and ocean energy. I will leave out the extensive details when mentioning these topics because they are not really a great feature in our South African context. Learners can be told what they are, but there is quite a large quantity of content knowledge in the other types of renewable and non-renewable energy that is current and growing in popularity in our country. In my opinion, these aspects should more be the focus of our lessons".		
Question 9				Perhaps in the future, a separate resource could be created for Natural Science teachers **with less detail**, but still having the appropriate diagrams of the latest technology in Renewable Energy.	CEQ, L107-109
Document Case E (CE) Account of Lesson 1 (AL) (CEAL1)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CEAL 1**		**Learning Task Sequence**	**Value added**	**CEAL1**
I started my lessons by showing my students the video	CEAL 1, L3	1		It is a magnificent video. They enjoyed watching it, but because it did not have subtitles, it took me a bit of time to explain the content on the video.	CEAL1, L3-5
My second lesson was on the differences between renewable and non-renewable energy sources. I gave them four pages of notes which summarised on global warming, making electricity at a coal power station and the national grid and how it functions	CEAL 1, L5-7 CEAL 1, L7-9	2	This was followed by a question answer worksheet in which they had to answer a few questions on what was taught so far		
Tomorrow I am explaining how to calculate the cost of using electrical appliances	CEAL 1, L9	1			

Once I am finished teaching how to calculate the cost of using electrical appliances, my students will do a mini project in which they compare the cost of using various appliances in their own homes.	CEAL 1, L11-13 CEAL 1, L13-14	1, 2 3	This will be followed by online research on methods to save electricity. They will record their findings in the project.		
Document Case E (CE) Account of Lesson (AL) (CEAL2)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CEAL**		**Learning Task Sequence**		**CEAL**
The grade **8's focus on energy efficiency**.	CEAL 2, L4-9	1 2 3	I used the power point slide 5 to show energy efficiency by design, slide 6 on recycling, slides 2 and 3 on solar heating and energy efficiency in domestic appliances. The students designed and made heat retention bags and boxes. We cooked food in hay boxes.		
With the grade **9 students**, I used the material to show images of renewable source electricity production and the greenhouse effect. I will send you photos of their circuits. We will still be building the solar cookers.	CEAL 2, L12-17	1 2 3	I will scan a few copies of learner's work done with the Cost of Electricity Project and send you copies. We completed the costing part of the project. On the 24 August we came to the MTN Sunstep Centre in the Stellenbosch University's Engineering faculty and assembled an electronic circuit called a light dark indicator circuit which forms part of the sustainability project. Students learnt how it saves electricity to have the lights switching on only when it is dark enough for it to do so		
Document Case E (CE) Interview 1(I1) (CEI1)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CEI1**		**Learning Task Sequence**	**Value added**	**CEI1**
The teacher emailed the researcher the worksheet she developed for the learners.	CEI1	1		Keep in mind that they struggle with language and can't read very well, so I have had to modify some of the notes you created to make it appropriate for them.	CEI1, L 31-34
Document Case E (CE) Interview 2 (I2) (CEI2)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CEI2**		**Learning Task Sequence**	**Value added**	**CEI2**
An email was sent to clarify certain answers on the questionnaire. My school has approximately **110 students**. All students are deaf or hard of hearing. We teach through the medium of	CEI2				

English. I can't remember when I did the short course. I think it was in 2013. It was arranged by Kasief Dilrag, the metro central school district Natural Sciences subject advisor and was held at Rhodes High School in Mowbray. All Natural Science teachers of the district were invited.					
Document Case E (CE) Interview 3 (I3) (CEI3)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CEI3**		**Learning Task Sequence**	**Value added**	**CEI3**
We also had a speaker, called Vivian Bluemel who visited us yesterday. I invited her because my school signed an eight year contract with the company that she works for in which they rent us PV systems and we pay them for it over a period of 8 years. She took the students on a tour to view the panels and spoke about how they work.	CEI3, L 7-14	1, 2	She brought solar (PV) components and circuit components, gave a talk on solar power and did an experiment with the grade 7 to 9 learners at my school involving ammeters, voltmeters, solar PV panels (tiny ones) in which they built small circuits measuring the voltage and current with the tiny solar panels in the circuit.	Enrichment	
Document Case E (CE) Interview 4 (I4) (CEI4)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CEI4**		**Learning Task Sequence**	**Value added**	**CEI4**
Using energy in a sustainable way. The hay boxes are used to cook food without a stove. Once the food is assembled and placed in the hay box in a pot with a tight fitting lid, it cooks by itself. The pot of food is heated to boiling point on a stove, before placing it in the hay box; it continues to cook using the heat energy that is already in the food.	**CEI4, L20-27**	**2, 3**	This is called heat insulated cooking. The hay box is closed with a bag of hay and a cardboard lid. We made vegetable soup, which was ready to eat after leaving the pot in the hay box for 3 hours. This is a great way to save energy because you are not using electricity to heat the pot of food for the full duration of the cooking time.		
Document Case E (CE) Learners Work 1 (LW) (CELW1)	**Code Line (L)**	**Quadrant**			**Code Line (L)**

Activity	CELP		Learning Task Sequence	Value added	CELW
The teacher designed notes and an Energy worksheet for the learners on Energy and Change	CELW 1, L1				
The worksheet consists of the following: Energy • What is energy? • Non-renewable energy • Environmental impact of global warming • Renewable energy sources	CELW 1, L 2-6	1	Introduced key concepts to the learners. Introduce the learners in using language and other forms of the knowledge displayed		
Electricity generation • Electricity generation and the national grid • How is electricity generated? • Generating electricity in a coal power station • Disadvantages of using coal to generate electricity • Advantages of using coal to generate electricity	CELW 1, L				
The cost of electrical power. • What is electrical power? Calculating power. • The cost of energy consumption. • Eskom home power tariffs • How to save (use less) electricity.	CELW 1, L	1 2 3			
Alternative sources of energy • solar power • wind power • hydro-electric power • biomass energy • nuclear power • geothermal energy • ocean energy	CELW 1, L				
Safety with Electricity **Electric Circuits** **Forces**	CELW 1, L 27-41		This is part of the Natural Science Curriculum and not part of the Renewable Energy material		
Learners did worksheet 1 on Energy and the Generation of Electricity with fossil fuels	CELW 1, L131-159	2	In worksheet 1 the teacher covered the generation of electricity from fossil fuels and the impact of it. Scaffolding		

Questions 2. Name three types of fossil fuels.	CELW 1, L134	2			
5. Air pollution is caused by the burning of fossil fuels. Explain why this is so	CELW 1, L139	2	Impact on the environment		
8. How do greenhouse gasses cause "Global Warming"?	CELW 1, L144	2	Greenhouse gasses		
10 Global warming causes the temperature of the earth to go higher. Give four negative consequences of global warming.	CELW 1, L148	2	Global warming		
11. Which source of energy is mainly used for generating electricity in South Africa	CELW 1, L154	2	Coal		
Document Case E (CE) Learners Work 2 (LW) (CELW2)	**Code Line (L)**	**Quadrant**			**Code Line (L)**
Activity	**CELW 2**		**Learning Task Sequence**	**Value added**	**CELW2**
Project: Calculating the cost of running different household appliances	CELW 2	2	The teacher designed her own project on energy use based on the energy assignment in the materials.		
Energy audit	CELW 2, L7-16	2	1. Make a list of electrical appliances 2. Find the power rating (watts) of each appliance 3. Convert Watts to Kilowatts 4. How many appliances? 5. Calculate the average kWh/day 6. Calculate the average kWh/month 7. Calculate the cost of each appliance 8. Draw a bar graph of the appliances		
"Concluding questions" were added on the cost of electricity	CELW 2, L19-47	2			
"Insulation for housing. Case Study: mushroom Insulation" for "sustainable housing"	CELW 2, L 47-63	2			
Evaluate the effective use of insulators in a house	CELW 2, L64-76	2			