GÖTEBORGS UNIVERSITET

Global warning? Never heard of it….

- A study about the meaning of the context in South African learners' acquisition of scientific knowledge

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”Inriktning/specialisering/LAU370”

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ABSTRACT

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Purpose

The aim of this Minor Field study is to illuminate the South African learners' understanding of global warming and how the learners' context affects his/her knowledge.

Central questions in this study are:

- How is the acquisition of scientific knowledge formed in the learners' understanding?
- What is causing the misconceptions of scientific knowledge?
- What do the learners know about the greenhouse effect and global warming?

Method

South Africa has a rich diversity of cultures and people, which gives us the possibility to investigate how the context is affecting the learners' understanding. To carry out this study we have used a triangulation of both quantitative and qualitative methods. According to the natural science approach we used a questionnaire as a quantitative way to measure the learners' scientific knowledge. To get into the context and to analyze that knowledge, we used the qualitative methods of observations and interviews. This enabled us to get into the aim of this study in more than one perspective.

We chose to write our study in English to be able to report the infomation back to our informants.

Results

Misconceptions concerning carbon dioxide, the greenhouse effect and global warming are many and are spread among the learners in our study. Many learners state that the proportion of carbon dioxide in the atmosphere is higher than the correct one. We can also see confusion in their conceptions of the effects of ozone holes and climate change. An explanation to these answers can be the "popularity" of carbon dioxide. In all schools, both teachers and learners described global warming as a current issue that is discussed in media and by politicians.

The process of learning in South Africa is affected by the social circumstances where different perspectives and opinions meet. This interaction is imprinted by the existing knowledge base, which is linked to a specific time, place and history. We illuminate the relationship between learning, knowledge and context. By elucidating potential, opportunity and precondition we get a better understanding of how these factors affect the learners' learning process.

Preface

This study took its beginning in November 2007, when we came up with the idea of applying for a Minor Filed Studies scholarship. This was when we began to spend all of our time awake, thinking about one of the greatest opportunities we could get in our lifetime, to integrate travel and school work.

We had to choose somewhere in the world where we could do our fieldwork. South Africa is a complex country in many respects, that found really interesting. There are many circumstances that affect the school situation in a country like South Africa. Things such as the history, apartheid, the current society situations, etc, will affect different people in different ways.

We got the scholarship and left Sweden and went to South Africa in the beginning of April 2008. A day-to-day life in an unfamiliar environment for more than two months, gave us more profound knowledge than we would get as tourists.

We have had a really good cooperation in every step of the way towards the final degree work, as this paper is. We have not only developed as teachers in the educating situation. We have also developed as persons in relation to other people and in our minds in relation to many different cultures, vulnerable life situations and humanity.

Gothenburg 21 January 2008

Lisa Andreasson & Therese Noborg

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ABBREVIATIONS AND DEFINITIONS OF TERMS USED IN THIS STUDY

All the following abbreviations and definitions are taken from the New Oxford Dictionary (McKean, Erin, 2005)

Climate change
Long-term, significant change in the climate of an area or of the earth, usually seen as resulting from human activity. Often used as a synonym for **global warming**.

Combustion
Rapid chemical combination of a substance with oxygen, involving the production of heat and light.

Context
The circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood and assessed.

In this study the context describes where the learners are situated due to education, background, socio-economics, color, class and mother tongue (our addition).

Global warming
The gradual increase in the overall temperature of the earth's atmosphere due to the greenhouse effect caused by increased levels of carbon dioxide, chlorofluorocarbons, and other pollutants.

Greenhouse effect
The trapping of the sun's warmth in a planet's lower atmosphere due to the greater transparency of the atmosphere to visible radiation from the sun than to infrared radiation emitted from the planet's surface. It is theorized that on earth the increasing quantity of atmospheric carbon dioxide from the burning of fossil fuels, together with the release of other gases, is causing an increased greenhouse effect and leading to global warming.

Greenhouse gases
Gases that contribute to the greenhouse effect by absorbing infrared radiation, e.g. Carbon dioxide and chlorofluorocarbons.

Load-shedding
Action to reduce the load on something, esp. the interruption of an electricity supply to avoid excessive load on the generating plant.

Misconceptions
A view or opinion that is incorrect because it is based on faulty thinking or understanding.

Ozone hole
A region of marked thinning of the ozone layer in high latitudes, chiefly in winter, attributed to the chemical action of chlorofluorocarbons and other atmospheric pollutants. The resulting increase in ultraviolet light at ground level gives rise to an increased risk of skin cancer.

Ozone layer
A layer in the earth's stratosphere at an altitude of about 10 km (6.2 miles) containing a high concentration of ozone, which absorbs most of the ultraviolet radiation reaching the earth from the sun.

Photosynthesis
The process by which green plants (including algae) and some other organisms use sunlight to synthesize food from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and generates oxygen as a byproduct.

Respiration
A process in living organisms involving the production of energy, typically with the intake of oxygen and the release of carbon dioxide from the oxidation of complex organic substances.

1. Introduction

During the theoretical part of our teachers' education in Natural sciences and work-placement we have developed an interest in the fact that all learners' learning and understanding are influenced by their background and experiences. Through previous studies we have discovered that the learners convert the information received in school, to make it more apprehendable. However, when they use their own experiences, the learners sometimes misconstrue the information. We have discovered that learners misunderstand the scientific knowledge that school and their education should give them. According to the Natural scientific approach in this study we see scientific knowledge as quantitative and objective. An important conclusion is that the scientific knowledge the school is obligated to mediate and the learning situation are linked to the context, the whole situation, and that preknowledge will affect the learners' understanding. We think it is important to identify random barriers that affect the learners' knowledge and understanding.

Diversity in the learners' preconditions and background affects the learners' possibilities in the meeting with school and its culture. We are interested in what contents of knowledge that are confronted in school today and what strategies that are used to make the learners develop a "true" understanding. By studying the learning situation from both an individual and social perspective we get the opportunity to understand the learners' development and his/her conceptions of different phenomena in the world.

Our work aims to study what kind of knowledge that is discussed in school and whose knowledge this represents. In school the learners need to take in a lot of different knowledge. An essential part of this integration is the learners' self-perception as an individual in a specific context. The process of learning is affected by the social circumstances where different perspectives and opinions meet. Both expressed and unexpressed rules and values make up the foundation of the social interaction that is dominant in society. This interaction is imprinted by the existing knowledge base, which is linked to a specific time, place and history. That is why we think that it is important to shed light on the relationship between learning, knowledge and context. By elucidating potential, opportunity and precondition we can get a better understanding of how these factors affect the learners' learning process.

There are many reasons why we decided to investigate the schools in South Africa instead of the ones in Sweden. Firstly we wanted to widen our views, so that we are able to see the Swedish school and all of our cultures from another perspective and with new eyes. Secondly, South Africa has a rich diversity of cultures and people, which gives us the possibility to investigate how the context is affecting the learners' understanding. We further think that by getting into another context than our own, we will have the opportunity to see and reflect upon differences that we would not see in our ordinary surroundings. According to The Curriculum for the compulsory school system, LPO 94: It is important to have an international perspective, to be able to see one's own reality in a global context in order to create international solidarity and prepare pupils for a society that will have closer cross-cultural and cross-border contacts. Having an international perspective also means develop an understanding of cultural diversity within the country. Thirdly, our contacts enabled us to visit the country.

We are trying to investigate how context is affecting the understanding of three specific topics: green house effect, global warming and climate change.

The topics we mentioned above are current issues all over the world, and more people start to be aware of the predicted effects. Thousands of scientific experts known as the Intergovernmental Panel on Climate Change (IPCC) concluded in 2007 that there is greater than 90 percent likelihood that people are causing global warming (IPCC, 2007). Furthermore reports of the expected effects of climate change in South Africa are mostly negative, especially when it comes to the impacts on human livelihoods, health, water resources, land and marine biodiversity, agricultural production and food security (Turpie, 2003; Van Schalkwyk, 2006).

But even though it is a current issue, everyone is not familiar with the topic:

What did you say? Global warning? Never heard of it…

Teacher in one of the schools we visited

2. Presentation of the problem

2.1. Aim of the study

Every learner holds knowledge that is based on his or her culture and earlier experiences. As teachers in Natural sciences our mission is to give the learners the opportunity to develop their prior knowledge to scientific knowledge. To enable this, the teachers need to understand how the learners are integrating new information with what they already known. In our study we develop our understanding and knowledge about this. By studying the context like background, environment, social factors and school situation we get more information about how learners acquire knowledge. We will develop as teachers as well; we develop knowledge to give our learners the best opportunities to learn.

The aim of the study is to illuminate how the learners' understanding of phenomena are affected by factors such as the context in which they are situated, and how the context can contribute to their learning process.

Central questions in this study are:

- How is the acquisition of scientific knowledge formed in the learners' understanding?
- What are causing the misconceptions of scientific knowledge?
- What do the learners know about the greenhouse effect and global warming?

2.2. Study outline

During nine weeks we have been able to study the context that South African learners are situated in. South Africa has a large diversity of schools and during our time in the country we tried to visit as many different schools as we could. The material for this study were collected from five different schools, one "white" private school, one "mixed" governmental school, one "colored" governmental school, one "black" governmental school and one rural school. Through our visits we were able to observe the learners' school situation in South Africa, and also to see the differences in the education situation due to the different schools contexts. To compare the schools we have chosen to study two specific scientific phenomena, the greenhouse effect and the global warming.

2.3. Disposition of the study

We collected the data during April-June 2008 in South Africa. Because of our contacts we got a "visiting schedule" for the five schools we were supposed to visit, one school every week for 2-3 days. The schools are located in and around Port Elizabeth. We handed out a questionnaire, did interviews and observations. We have taken all chances to talk informally to teachers, principals and learners at the schools in the study.

Initially we will present the aim of our study and then offer a description of the South African nation, in relation to the recent history to emphasize its impact on the reigning conditions in

the society. The investigation relates the matter of education in a cultural and historical context. The description of the educational system is also significant for the understanding of the context where our study took place.

The following presentation in chapter 4 covers basic information about carbon dioxide, greenhouse effect and global warming which is crucial for understanding this thesis. We try to describe these factors as accurately as possible so we can relate them to answers from the questionnaire and interviews.

In the next chapter on theoretical framework we present the difficulties of learning due to language and misconceptions that will be one of the most important foundations of this study. Chapter 6 on methods includes a discussion of methodological approach, sampling, reliability, validity and ethical considerations. It also includes an explanation of our fieldwork. This is done in order to present the "method triangulation", the questionnaire, interviews and observations. We also discuss some impediments and limitations that we are aware of, emphasizing this to increase the reliability of our study.

In chapter 7 we present our results. At first we elucidate all schools together and then we compare the different schools. The results are based on the questionnaire and we enhance it with extracts from the interviews and observations. The chapter that follows pursues a discussion about the aim of this study based on the results due to background, theoretical framework and the teachers and learners' approaches, thoughts and views. The last chapter may be one of the most important to us as future teachers. Here we bring up the relevance of this study to the teaching profession from a learning point of view. We want to present how teachers, in their way of understanding the learners' developing process and acquisition of scientific knowledge, can give them the best opportunities from an educational point of view.

3. Background

3.1. General facts about South Africa

Collected from Landguiden (2008) & CIA (2008)

Official name:	Republic of South Africa
Capital:	Pretoria
Area:	1,219,912 sq km
Population:	48,782,756
Constitution:	Republic
Language:	South Africa has 11 official languages: Zulu, Xhosa, Afrikaans, North Sotho, English, South Sotho, SiSwati, Tsonga, Tswana, Venda, and Ndebele
Ethnic groups:	Black African 79%, white 9.6%, colored 8.9%, Indian/Asian 2.5%

3.2. The inhabitants and language

The population of South Africa has in the recent years increased by a few percent per year. But due to the rising mortality of Aids and the fact that white inhabitants are emigrating from the country, a decrease in the South African population is expected.

Official statistics divide the population of South Africa into four groups: Africans, European, colored and Asian people. The population consists of 80 % Africans which are often named ”black” people.[1] The African population is subdivided into many groups. The largest groups are Zulu and Xhosa; other African groups are Swazi, Sotho, Tswana, Venda and Shangaan-tsonga. The major part of the white inhabitants are Afrikaans (Boer), the second largest are the English speaking group, most of whom are descendant of the British settlers which arrived in South Africa in the 1800s. The majority of the Asian people are Indy, which were recruited by the British at the time of their settlement. The colored people descend from the mix of Dutch settlers, the Khoi and slaves from Africa and Asia, who were imported by the white people (Guelke, 2005; Landguiden, 2008).

3.3. South African History

South Africa first became known to Europe when Bartholomew Diaz 1487 rounded the Cape in his search for the sea route to India. The Cape was later on used as a resting place by the English and Dutch vessels on their way to and from India. In 1652, the Dutch East India Company established a fort at Table Bay (Cape Town). From the time of their arrival the Dutch settlers started to expand in the region and the first group to be affected by the Dutch settlers was the Khoi Khoi people. The Khoi Khoi people were driven away or forced to work as servants. The white Europeans took control over the conquered Africans through a pass-

[1] Descriptions such as blacks, whites and colour are group distinctions still used in the South African society. We, personally, do not put any values into the words.

carrying system, which forced them to be restricted to certain areas at certain times. The Europeans also imported slaves from Malaysia, (which at this time was a Dutch colony) and the west coast of Africa (the colored people in today's South Africa is a result of mixed marriages between the slaves and the Khoi). The Dutch settlers developed a new language, Afrikaans, and named themselves Boer.

In the late 18th century The Dutch area stretched into the eastern region, which was largely occupied by the Xhosa people. While they were fighting the Xhosa, the British, who became the dominant people in the Cape Province in the beginning of 19th century, got the opportunity to establish permanent control over the Cape in 1806.

3.3.1. "The Great Trek"

During the time of British development in the Cape the Dutch settlers were excluded from land ownership, slavery was taken away and the freed slaves were put on an equal footing with the Christians. The Boers expressed their opposition to the British and moved in a mass migration out from the colony and formed two republics, the Transvaal and the Orange Free State. Africans who wanted like to visit this republic were required to carry passes and they were prohibited from registering land ownership, in the Orange Free State no Indians were allowed.

"The people desire to permit no equality between colored people and white inhabitants of the country, either in church or state."

- The 1858 constitution of Transvaal -

When diamonds and gold were found in the Boer area at the end of 19th centaury, the British wanted to rule and control the entire area of "South Africa". The conflict between the Boer and the British grew bigger and resulted in the Boer war in 1899. The British burned down 30 000 farms and put women and children in concentration camps. 26 000 Boer and 14 000 black people died in these camps. In 1902 the declaration of peace was signed and the Boer lost their independence in Transvaal and the Orange Free State. Even though British ruled, the Boer was given more influence as time passed. The British and the Boer together constituted the South Africa Union in 1910 and English and Dutch became the official languages. The same year the first election was won by the Boer dominated South African National Party (later the South African Party, SAP). Only white people had the right to vote.

The union did not give the Black people any civil- or political rights. This discrimination rose strong reactions among the black people. An organization, The African National Congress (ANC) was established in 1912 to fight for the black peoples rights. The following years, racism was a fact and many laws, which discriminated the rights of the non-whites, were implemented. One example was the Land act of 1913 through which 87% of South Africa's land was given to the white people and 13 per cent to the Black people even though the majority of the South African inhabitants were Black.

3.3.2. Apartheid

The National Party (NP) won the election in 1948 and created apartheid, which literally mean the state of being apart. An important pillar of apartheid was the Population Registration Act in 1950. The entire population was classified by race, initially under three headings: Native

(which later became Black), White and Colored. The Colored people were later divided into seven subgroups. The vision of the NP was also that whites should live in the "real" South Africa and that blacks should be placed in "homelands". The intention was that South Africa should be left with no African citizens. Blacks were allocated to their homeland lost their citizenship in South Africa. Marriage and sexual relationships between the groups became illegal and all institutions were separated to prevent people from meeting. The different groups were given their own "cultural spaces" in the Group Areas Act of 1950 and through forced relocations; each group was separated to live in its "own area". Passport laws were implemented and blacks were forced to always wear documentation. It was a criminal offence to be unable of showing this document when required by the police. The Labor bureau 1952 decided that Africans needed permission to remain in an urban area for more then 72 hours.

The reservations of the Separate Amenities Act of 1953 removed all the government's obligations to ensure equality of provision to people of different races. The so-called Bantu education with crowded classrooms and uneducated teachers was designed so that the Africans could not get further education. The Extension of University Education Act of 1959 made it illegal to admit non-white students to the universities.

One year after the NP won the election the ANC started to show disobedience and presented an action program with strikes and protest marches against the apartheid government. The government responded by stating new laws those prohibitive protest meetings. The Sharpsville massacre took place just outside Johannesburg when the Pan African Congress (PAC) demonstrated peacefully against the passport laws. The police opened fire and 67 unarmed demonstrators were killed, 186 were seriously hurt. This was a turning point in the struggle to overcome apartheid. After this The African National Congress (ANC) and the Pan African Congress (PAC) began to use armed actions and performed acts of sabotage towards the government. Nelson Mandela, who became the leader of the armed ANC branch named Umkhonto we Sizwe (MK) was imprisoned on the 5th of august 1952. He was sentenced to life imprisonment and total isolation from the rest of the world on Robben Island, Cape Town.

The violence escalated as the government responded to the armed opposition, and a new massacre took place in 1976 when black students in a township protested against the introduction of Afrikaans as the teaching language in black schools. This resulted in a large media cover and international opposition to the apartheid regime increased. During the 80s many countries started to support the ANC and introduced sanctions towards South Africa. The violence reached its peak in 1985 and in an attempt to calm the people; the government erased the passport law. This did not calm the opposition and dissatisfaction continued to rise. To reach a solution to this untenable position, secret meetings were held between Nelson Mandela, the president P.W Botha and his successor F.W de Klerk. Nelson Mandela was eventually released in 1990 after 27 years in prison and ANC and PAC became legal parties. The 27th of April 1994 the first democratic election in the history of South Africa took place. ANC won with 64% of the votes and Nelson Mandela was elected president.[2]

3.4. South Africa – post-apartheid

[2] The historic summary is written with our own words, only dates and years have been collected and/or verified with Guelke (2005), Van der Berg, S. & Louw, M (2004), Eades L.M. (1999), Omer-Cooper (1994) , Eriksson & Lindgren Andersén (2007) from Holmström and Siverbo (1998)

South Africa is a complex country with a rich history, plagued by oppressive leaders throughout centuries, beginning with colonialism and ending with the system of apartheid 1948. During apartheid South Africa was synonymous with racism and major inequalities. The white population had living standards matching the richest countries in the world. In contrast the majority of the black and colored population lived in conditions typical of the poorest third world countries.

The fact that ANC won the election in 1994 is fundamental for all levels of South African society and the constitution of 1996 was a huge turning point in South African history. The constitution declares that South Africa should be founded on values such as: Human dignity, the achievement of equality and the advancement of human rights and freedoms, non-racialism and non-sexism.

The aim of the South African constitution is also to:

- *Heal the divisions of the past and establish a society based on democratic values, social justice and fundamental human rights;*

- *Improve the quality of life for all citizens and free the potential of each person*

It furthermore declares that everyone has the right –

- *To an environment that is not harmful to their health or wellbeing.*

- *To have the environment protected, for the benefit of present and future generations.*

The constitution of 1996 also contained an education policy, the aim of which was to erase discrimination and prejudice. The policy states that everyone, regardless skin colour or ethnic belonging has the right to a basic education. The education plan resulted in free and obligatory schooling for everyone, a common curriculum and that all schools became accessible to all learners. The Education Policy was also aiming at introducing education in the learners referred language, assuming it is practicable and the language is one of the eleven official languages in the country.

Despite the constitution, South Africa today is still grappling with prejudice, often in form of racism. The country's history has resulted in a society characterised by socio-political changes (The South African constitution, 1996).

With the installation of the first democratically elected South African government in 1994, the scene was set for transformation on all levels of human existence. In addition to this change, the country is faced with the challenges of socio-economic development, globalization, technological advancement and cultural diversity, amongst others. Owing to the rapid rate of change on many levels of human existence, our learners find themselves living in a world different from that in which their parents lived. As South Africans, they also have to find ways of operating in an emerging democracy. Furthermore, social, economic and environmental issues affect the current and future health and well being of individuals and communities alike. Within this context, learners have to be well informed and have a sense of confidence and competence to live healthy and productive lives while contributing to the shaping of a new society.

National Curriculum Statement, Grades 10-12, Life Orientation p.8

South Africa is not only wounded by its past. Beside racism they also struggle against poverty and high unemployment rates. In 2002, 48.5% of the population in South Africa was living in poverty according to the UNDP (United Nations Development Programme), 2003, 23.8% of the people was living on less than two US dollars a day, and 10.5% on less than one US dollar a day (UNDP, 2003). Even though the number of unemployed has decreased in the last few years, 23% of the population is still out of jobs (Labor Force Survey, 2007). On top of this, approximately 5.5 million people are living with HIV in South Africa, which makes the country the one with the largest number of infections in the world (UNAIDS, 2006).

3.5. Orientation in South African school / education system

The School education was introduced in South Africa during the 18th and 19th centaury by the Dutch and British colonizers. [3] Missionaries who wanted the inhabitants to convert to Christianity organized the education. The fact that the British missionaries draw most people to education resulted in English as the head language in school. When the Government at the end of the 19th century decided to make Afrikaans equal to the English language a larger number of white learners started school.

Like everything else in South Africa, education was affected by the 1948 system of apartheid. Inequity between the ethnic groups due to the system led to an even more increasing segregation in the society. Blacks, coloured and Indian people were denied proper education. The Bantu education from 1954 was aimed to maneuver black or non-white youth to the unskilled labor market or job as servants. The education plan of the Bantu Act mainly focused on black boys learning gardening and woodwork and girls learning to take care of the household (Holmström and Siverbo, 1998).

"There is no place for [the African] in the European community above the level of certain forms of labour. It is no avail for him to receive a training which has as its aim, absorption in the European community."

HF Verwoerd, the architect on the Bantu Education Act
(South Africa. info, 2009)

Non-whites were considered only suitable for certain types of jobs and the only groups offered education were teachers, hospital staff and policemen. The teacher's education for blacks was two years, for whites five years. The white government decided the content of the black teacher's education, and consequently what they later would teach their students. During the apartheid years only white people were allowed higher education (Holmström and Siverbo, 1998).

3.6. The modern school

Modern school education in South Africa covers 13 years and the first nine years (grade 1-9) of them are compulsory. Grade R, Reception year, are comparable to F in the Swedish school system. The children attend school from the year they turn 6 until they turn 15 years old.

[3] By school education we mean European School education. Many African societies practised traditional forms of education before the arrival of the Europeans, which consisted of oral histories, tales of heroism and treachery, and practice in skills necessary for survival

These compulsory years are divided into different phases. Grade 1 to 3 is called the Foundation Phase, year 4 to 6 the Intermediate Phase and year 7 to 9 the Senior Phase. These 9 years is called the GET (General Education and Training) Phase. The South African education system (R to 9) consists of 8 subjects:

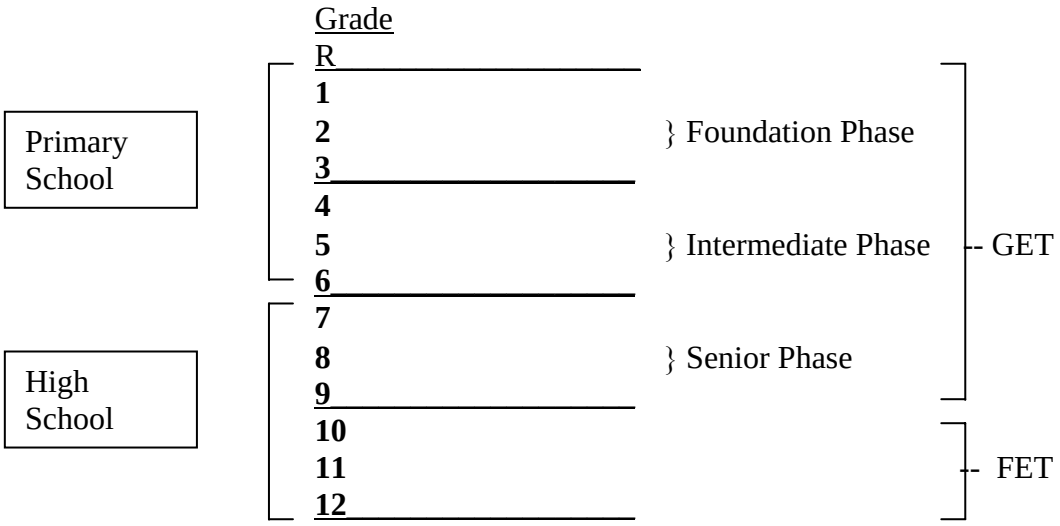
- Art and Culture
- Technology
- Mathematics
- Science
- Social Science
- Languages
- Economic management
- Life Orientation[4]

These subjects all have different aims that the learners have to reach at the end of grade 9. Every school year they have to reach a part of the aim.

The Foundation Phase is a basic education and consists of three major parts: Literacy, Numercy and Life Orientation (LO). The central points in the intermediate Phase are literacy and Numercy, but the learners are still educated in LO. The Senior Phase prepares the learners for the Further Education and Training Phase (FET). The four most important subjects in the Senior Phase are LO, mathematics and two official languages. But the learners still get education in the other subjects as well.

The FET phase involves grade 10, 11 and 12. In this phase the learners must study two official languages (of which one is their mother tongue), mathematics or mathematics literacy and LO as compulsory subjects. In addition the learners must choose 3 of the other subjects offered at the school. The number of subjects at the school depends on available teachers.

Model of the school system in South Africa



[4] LO is divided in four sections: Personal Well-being, Citizenship, Recreation and Physical Well –being and Careers.

Grade 12 is also called the matric. The marks from this grade are important to get access to the university. At the end of the year all learners write exams to get the National Senior Certificate. There are exams in all subjects, and how many exams each learner writes depends on how many they have chosen to be educated in. The results from the exams are announced in the newspaper with details about all learners, whether they failed or passed. In the Private Schools these exams are called IEB, Independent Examinations Board Senior Certificate and are similar to the examination in the governmental schools (South Africa. info, 2009).

3.7. A complicated school in a complicated country

Like so much else in South Africa, the education system is characterised by diversity. Schools vary in terms of quality and resources. The former white (model C) schools are still having higher standards, more resources and better reputation while the traditional black and coloured schools struggle with bad economy, lack of resources and bad reputation. This has created a situation were many black and coloured learners are moving to the former white schools but not the other way around (Sandqvist, 2008).

"We have two education systems in South Africa. In the one we have rural and township Schools characterized starkly by poverty, and in the other we have former Model C Schools characterized by being well resourced due to the legacy of the past. Dysfunctional, vulnerability, alienation and a lack of social cohesion characterize many of the township and rural schools.
The State has the primary responsibility to ensure the enjoyment of the right to basic education. Much has been done since 1994 and for this due credit must be given. Resources have been poured into schools in order to ensure equal treatment. However, resources are not enough. Of more concern is that in the South African context, recent research indicates that we are not seeing the outcomes in terms of quality education that were anticipated."

Human Rights Commission, 2006, p.2

The human rights commission (2006) reports that poverty has impacts on the quality of education, due to the disability to pay school fees and other hidden costs such as textbooks, uniforms and transport costs. Other reported issues are:

Teachers -

- lacking passion and a culture of learning and teaching
- not being in the classroom enough;
- being unqualified or underqualified,
- using old teaching metods,
- having too much children in their classrooms,
- being disconnected from the community in which they teach

Lack of teaching supplies and school premises and the fact that many learners do not understand the language their teacher speaks are also resulting in a loss of quality.

"Those children who are most disadvantaged in enjoying the right to a basic education lack the means and the social power to speak out and claim their rights."

Human Rights Commission, 2006, p.3

4. Basic Information

To understand the presentation and be aware of some basic knowledge about the three specific scientific topics, carbon dioxide, greenhouse effect and global warming, the following explanations are necessary.

4.1. Facts about carbon dioxide

At the moment, South Africa has a per capita output of about nine tons of carbon dioxide (CO_2), mainly because 90% of the country's electricity comes from coal-fired power stations (EIA, 2009).

A molecule of carbon dioxide is straight and non-polar, consisting of one atom of carbon and two atoms of oxygen that are attached to each side of the carbon atom with double bonds. Carbon dioxide is a gas in room temperature but in low temperature (-78 °C) and/or in high-pressure the carbon dioxide transforms into liquid or solid form. The carbon dioxide gas is color- and odorless and may contribute to a stinging feeling in mouth and throat. Carbon dioxide is not toxic in small amounts, but in high concentrations it may lead to headache, nausea, dizziness and unconsciousness and choking (Nationalencyklopedin, 1993, our translation; Air Liquid).

Carbon dioxide is produced when carbon-containing compounds (organic) are burning. It is naturally present in our atmosphere to the amount of 0,038 %. Carbon dioxide is one of the so called ”greenhouse gases” that absorbs radiated heat from the surface of the earth. If it were not for the greenhouse gases in the atmosphere the average temperature on the earth would be -18°C, which would be far too cold for most species to exist. Because of the greenhouse gases, the average temperature is relatively warm, +15°C. Certain human activities, such as burning fossil fuel, result in higher concentrations of carbon dioxide in the atmosphere which contributes to the enhanced greenhouse effect. Even though carbon dioxide also is produced in combustion of biofuel, this is not said to contribute to the increased amount in the atmosphere. Biofuel are rapidly recreated and absorb the same amount of carbon dioxide as let out while burning. Carbon dioxide is also produced in volcano eruptions

The plants’ photosynthesis is essential for life on Earth. The plants depend on the inorganic carbon dioxide as a raw material in this process. Photosynthetic organisms absorb millions of tons of carbon dioxide each year. With help from the energy of the sun the process transforms carbon dioxide and water to organic carbon-compounds. Oxygen is also produced as a waste product, and this waste product is essential for humans and animals.

All living organisms are based on the photosynthetic carbon-compounds. The fixed carbon returns to the atmosphere via decomposition of organic material, fires and as a waste product of cellular respiration, which are exhaled, from the organisms (Palm. H, 2007; Campbell, 2006; Nationalencyklopedin, 1993).

The ocean absorbs carbon dioxide firstly through the photosynthetic alga and aquatic plants and secondly through dissolving it in the water. The ocean contains 50 times more carbon

dioxide than the atmosphere. The largest carbon dioxide reserves are stored in the crust of the Earth fixed in minerals. Constant exchanges are taking place between these storages, in the cycle of carbon. The movements of carbon in some circulations are rapid, like when carbon dioxide in the atmosphere is absorbed by plants and used in the photosynthesis. The carbon returns to the atmosphere via cellular respiration and the action of decomposers. The burning of fossil fuels is a part of a slow cycle, because the production of coal, oil and natural gas requires long term storages deep in the surface of the Earth.

In an article, Håkan Palm (2007) says that carbon dioxide is neither the most effective nor the most common greenhouse gas today. More than two-thirds of the greenhouse effect is a result of the water vapor, but we talk about the carbon dioxide more because it is a result of human activities. Other anthropogenic greenhouse gases are methane, chlorofluorocarbons and ozone that form in chemical reactions from pollutants near the ground (Nationalencyklopedin, 1993; IPCC, 2007).

4.2. Greenhouse Effect

When the weather outside is too cold to grow plants a greenhouse can be used. Solar radiation are allowed to pass the walls of glass heating the soil, which in turns warms the air and results in an increasing temperature inside the greenhouse. Comparable to this, a process called the greenhouse effect operates on a global scale.

The radiation from the sun, containing ultraviolet radiation and visible light among others, reaches the Earth. The most damaging radiation (UV) is filtered out by the ozone layer, and the visible light warms the surface of the Earth through absorption. Heat in the form of longer infrared wavelengths is emitted back from the Earth into the atmosphere. Gases, which are known as greenhouse gases, absorb some of it and then some of the heat is radiated back to Earth. This is a natural and essential process of life on the planet Earth. Without this process, Earth would be a cold and unpleasant planet to live on.

There are several gases in the atmosphere that contribute to the greenhouse effect. Some of the greenhouse gases occur naturally like water vapor, carbon dioxide (these two are the most important ones), nitrous oxide, ozone and methane. Others are produced by humans and are synthetic, like for example chlorofluorocarbons. Although the greenhouse gases occur in small amounts these gases allow about half of the incoming solar radiation to reach the surface of the Earth, but limit the outward passage of the reradiated heat into space.

Since the Industrial Revolution in the 18th century, when we started to use a lot of fossil fuels the amount of carbon dioxide has increased by almost 30% (Campbell, 2006).
The increasing level of the carbon dioxide in the atmosphere has been noticed for a long time. A Swedish scientist, Svante Arrhenius, already in 1896 had some thoughts about the atmospherically carbon dioxide.

” His fundamental conclusion, about fossil fuels combustion, the radiation balance of the Earth system, and the global climate, has been solidly confirmed.” He saw the link between carbon dioxide, the global climate and human activities”

(Field et al, 2004, s.1).

4.3. Global Warming

IPCC (Intergovernmental Panel on Climate Change) reports that carbon dioxide is the most important anthropogenic greenhouse gas. The amount of carbon dioxide in our atmosphere have increased by 35 % since the start of the industrial revolution, this is the result of the fossil fuel use. IPCC also reports that the effects of global warming we see today, like climate changes, ice melting and increase of the sea levels, do not only have natural causes. They state that human activity must be the reason for this increased amount of greenhouse gases. Consequences of the global warming will turn in to a catastrophic loss of species all over the world. Scientists report that the biological diversity in South Africa is one of the most endangered in the world. This is because animals and plants do not have the ability to "escape" further south. The Antarctic continent is too cold and too far away. Some scientists also split Africa into three zones, the dry one, the wet one, and the insecure one. The dry one is in the north, where they predict that the amount of rain will decrease to 400 mm per year; this will result in ravage consequences for humans, animals and plants. More rain in the wet zone will end up in more still waters, more mosquitoes and more malaria. South Africa is part of the insecure zone, where the scientists are unsure about how the global warming will affect all living things.

One fourth of all plants and animals around the world risk to be extinguished because of the climate changes. One example is South Africa's national flower, the Protea, which in a couple of years will disappear from the planet Earth.

5. Theoretical framework

This study is based on two separate scientific perspectives, which are the socio-cultural and natural sciences. We are aware that these two paradigms are often discussed as opposed and in contrast to each other. As teacher students in natural science we have been taking part of both of these perspectives. The natural scientific approach is a quantitative and objective way to measure knowledge. The measuring of the learners' natural science based knowledge (and the misconceptions that exist) is in our study a kind of concrete measuring point. We will later, using these measure points, investigate if the learning process is affected by socio-cultural factors. In this way we can measure the knowledge quantitatively and objectively, but also analyze and discuss it as qualitative and subjective.

5.1. Sociocultural learning perspective

The Russian cognitive psychologist Lev Vygotsky, also known as one of the most important actors in the socio-cultural perspective of learning, deals with contextually questions. He wrote a lot about the culture that the learners bring to school and the culture in the classroom. He was concerned with the way culture can influence learning. Vygotsky was most interested in combining knowledge about the neurological and physiological functions of the brain with knowledge about acquisition. He saw the importance of culture and language in learning. He also points out the importance of internal and external aspects. Children learn by assigning meaning to objects and events as they speak to each other. Not only the speech is important, but also the senses. Learning depends on the external environment and the internal processing of information. Vygotsky pointed out that culture makes a social process possible and that language makes thought possible (Barba, 1998).

Before the children enter school they project themselves according to the adult activities in their culture. This leads to the development of their future roles and values. When they enter school they already have developed a way of learning based on their culture and background. If comparing children from different cultures we will find that they will have different ways of knowing and learning. This perspective of learning, Vygotskian and sociocultural, says that culture has tremendous impact on learning in school (Ibid).

Theoretics in the socio-cultural perspective claim that it is the physical and social contexts, that is important in learning. The verbal arena is the most important to the way of learning. Today, English has become the common instructional language in South African schools, because of its status as a second language for many learners. In grade 1-3 the learners are taught mostly in the mother tongue but from grade 4, they are taught in English to a large extend. Research shows that if learners are educated in their mother tongue they will

- get better self-esteem
- improve their attitudes towards school
- facilitate content area acquisition of knowledge

Knowledge can only be constructed when it is integrated with already existing knowledge. The learners need to elaborate with the already known to understand new phenomena. To allow the learners to use their mother tongue in certain discussions will give them the opportunity to do this elaboration (Ibid).

Teaching, tutoring, and supporting are what a teacher is essential for in the development of knowledge for the learners. The verbal tools we use in our everyday life have been created in the culture we have. Humans do not need to experience everything by themselves to achieve knowledge. They can learn through communication and when others describe their experiences. If the learners communicate with each other with words they already know, the probability that they will develop their knowledge is superior. The language is used both "inwardly" in the mind and "outwardly" to communicate (Säljö, 2005).

5.2. Misconceptions

When we are trying to understand new phenomena we use cultural and verbal tools in the elaboration, reflection and development of knowledge. We acquire conceptions that are the best description of the phenomenon due to the prior knowledge we have. The tools seem to be natural, but they are founded in the communication and interaction with others. We use these tools to deal with new situations, which contrast with our prior knowledge (Säljö, 2005).

Failing to understand can have a variety of reasons. For example the learner may not be able to understand because of a lack of prior knowledge or not knowing what is relevant. It can also be because of they cannot establish a relationship between the new and the prior information. Misconceptions may occur in many different ways. They can develop from misinformation, teachers are teaching the learners the wrong information about a phenomenon, and the textbook may give a wrong picture. Other problematic misconceptions may be acquired through direct and limited experiences of the phenomena in the world (Newton, 2000).

5.3. Prior studies

There are previous studies about learners' conceptions regarding natural science. Many of these studies have been summarized in a book of Björn Andersson named *Learners thinking about natural science in school* (2001). He describes one project, which was carried out by of the National Agency for Education, who is responsible for the evaluation of the Swedish school system. The project was called Theme State of the world and was part of the 1998 program. In chapter 4, Andersson reports that only 5% of the learners in high school are able to explain the greenhouse effect. He also reports that learners tend to mix up the ozone depletion and the increased greenhouse effect. 76% of the pupils in grade 12 in high schools that believe that the ozone layer is contributing to the global warning. Andersson also write that 60% of the learners state that carbon dioxide have an impact on the ozone layer which results in depletion. However 71% do know that humans are not able to live on earth without the greenhouse effect.

The report also states that some learners are describing the courses and/or the consequences of the greenhouse effect and its increase when they are explaining the phenomenon. A common misconception among the learners is that the greenhouse effect is a cap or a layer, which keeps the heat inside. Andersson, B. (2001) also reports that the learners have a common idea that the greenhouse effect is something negative, which is a result of them mixing the natural greenhouse effect and the increased greenhouse effect.

Stefan Strömberg (2004) reports that the learners' conceptions are highly studied and the conclusion is that the misconceptions are strongly dominating. Strömberg also agrees with Andersson (2001) who thinks that the teaching has to start from the learners' idea of the world and that this is the only way to create a challenge between misconceptions and scientific conceptions. Andersson also thinks that misconceptions are a starting point for the learning process.

Svein Sjöberg (2005) looked into the ROSE-project, an international research project that is working to make the subjects in natural science more meaningful, interesting and relevant for the learners. Sjöberg also writes that all good teaching has been based on the learners' pre-knowledge and interests. Motivation and meaningfulness are necessary for learning.

According to Boyes & Stanisstreet (1993) education is best designed when it is based on knowledge of the learners' level of knowledge and preconceptions. Through this, information can be selected and organized to fill known knowledge gaps, enhance understanding and resist misconceptions.

During the last part of the 20th century a number of researchers have studied learners' understanding of global warming, its causes, consequences, and "cures." Boyes & Stanisstreet (1993) state that learners (from age 11 and up), in general know that global climate change is related to changes in the weather patterns. According to the writers the learners are also able to basically describe how the greenhouse effect works to increase temperatures in the lower atmosphere. However, learners as well as teachers, frequently hold incorrect perceptions about the phenomenon. Boyes & Stanisstreet write that results regarding misconceptions are remarkably similar across education levels.

The most common misconceptions among learners are, according to Gowda, Fox and Magelky (1997):

- confusion between CFCs, the ozone hole, and climate change. Learners state that ozone layer depletion causes climate change and that by stop using aerosols we prevent global warming.

- perceived evidence- warmer weather. Learners report that they could sense rising climatic temperatures or changes in long-term weather.

- all environmental harms cause climate change (aerosols, acid rain, even solid waste disposal)

6. Method

6.1. Methodological approach

In the context of research you usually choose between two main methodological traditions to collect material. These methods are called quantitative and qualitative. The quantitative methods used to investigate the quantity, that is to say, the amount of a measurable entity of a certain phenomenon or the relation between different phenomena. The benefits of the quantitative methods are the possibility to work with large material to show tendencies or likelihoods. The disadvantages of this method of research is that it only gives us wide and general answers and that you sometimes have to simplify complex phenomena to make them measurable. Some would find the quantitative method shallow and hard to get a more nuanced understanding of certain phenomena.

The qualitative methods are on the other hand used to investigate the quality, the character of a phenomenon so to speak. The benefits of qualitative methods are the possibility to describe in detail complex phenomena and processes. They also give the opportunity to understand and explain human actions and put them into context, making them more comprehensible. The disadvantages of the qualitative methods are that they are often limited to fewer individuals due to their time-consuming approach (Stukát, 2005). Basing our study only on qualitative methods would give us (according to ourselves) a subjective result, affected by our own perspective, experiences and thoughts.

By using a quantitative method in form of a questionnaire and qualitative methods in the form of interviews and observations, we get the opportunity to receive information from different perspectives. Using different methods we try to circumscribe the problem from several angles in order to place it at the centre of the study. This is called ”method triangulation”. The three methods of using questionnaires, observation and interviewing complement each other and that are more beneficial for us in the final result of this study. (Stukát, 2005)

6.1.1. Questionnaire

By using a questionnaire to collect material we can receive a good base of answers quickly. We also get information from all the learners in one class. By using a questionnaire you also avoid the “interview-effect” which means that the participants, consciously or unconsciously, are trying to show “their good side” to the interviewer. Another positive thing when using a questionnaire rather than interviewing a person is that he or she does not have to feel uncomfortable answering personal or sensitive questions face to face with the interviewer (Trost, 2001).

Our questionnaire was composed of 11+8 questions and consisted of two parts. The first part in our questionnaire was aiming to collect background information about the learners: Where they live, how they live and what their everyday life looks like. The questions in the second part of the questionnaire were directed towards the learners’ knowledge of the greenhouse effect and global warming. Many questions had non-open answer alternatives that made the compilation of the result easier. One question had an open answer alternative and the point of

this was to make the learners use their own words to describe what they know or believe. We are hoping that the answers will give us a good idea of the learners' knowledge about the greenhouse effect and the global warming and other related phenomena such as photosynthesis and combustion.

We have tried to write the questions in the questionnaire as neutrally as possible to avoid "leading" the learners to the correct answer. To increase the validity and motivation among the learners, we both participated at the collecting of the questionnaire. The result from the questionnaire was processed in Microsoft excel.

6.1.2. Interview

To get more qualitative and profound information we also did interviews with both teachers and learners in all schools. The questions in our interviews are what Stukát (2005) would call half- or semi-structured questions, and most of them are open ended. Like the last question in the questionnaire the questions have a descriptive character to get the participants to open up their minds and discuss the phenomena from the point of view of understandings and thoughts (Johansson & Svedner, 2006). This gave us more worthwhile information about attitudes, approaches and concerns in the school situation.

We chose to interview one teacher and two learners in each school we visited. Our requirement was that the teachers we interviewed had to educate high school learners (sometime during the school year) about global warming. These teachers are educated in different subjects, such as Geography, Life Orientation and Biology. The differences depend on the fact that the phenomenon of global warming is brought up in different subjects in the different schools. Three of the interviewed teachers are females and two are males. They are between 30-60 years old and have been teaching for 7-34 years. One teacher is black with Xhosa as mother tongue, one is colored and Afrikaans speaking, two are white and English speaking and one is white and Afrikaans speaking. All of them speak English during the interviews. All teachers we asked gladly agreed to be interviewed.

The learners we interviewed were volunteers from the 10 Grade classes in which we had handed out the questionnaire. In some cases we asked the teacher to pick two "average" learners in the class, so we would get those with average level of knowledge. We decided to interview the learners in pairs, this to make them feel more comfortable in the situation and give us better and more detailed answers. We did not take any notice of other parameters like sex or age. One of the interviews is with two girls, one is with two boys and three are with one boy and one girl.

The principal was informed about how, when and where the interviews were taking place. We did not need to have the parents' permission to do the interviews. All interviews were recorded and written down on paper.

6.1.3. Observations

During our visits to the schools we had the opportunity to sit in during lessons. The point of this was to observe the teachers and learners in "action". Through our unstructured observations in the classroom we could not only get information about the teachers' knowledge, but also see the teachers' way of educating the learners. We also observed other

lessons with other (not interviewed) teachers to find out the learners' school situation. In this way we could get more superior information about the context in which the learners are situated.

We are aware that our presence in the classroom may affect the behavior of the teacher and the learners. We tried to avoid this by introducing ourselves (to make them less curious) and explaining that we only wanted to sit in and watch the lesson. After our introduction we tried our best to stay "invisible" in the back of the classroom.

6.2. Sampling

Considering our previous lack of knowledge about the schools in South Africa and the relative short visit in the country we asked our contact persons to arrange our meetings with the schools. We tried to explain the purpose with our study and expressed our wish to visit as many different types of schools as possible. Our selection of participants consequently became a selection by convenience. The material in this study is collected from five different schools, one "white" private school, one "mixed" governmental school, one "colored" governmental school, one "black" governmental school and one rural school. Looking back and considering our new experiences from the country we think that we have got a good selection, covering many of the different types of schools in the country.

To make it possible to compare the different schools we chose to make the study in the same grade in all schools. Grade 10 felt like a good selection, considering that all of the learners have been educated about global warming quite recently (in grade 8 and 9).

We will first and foremost use the result from all schools together to present a general picture of all learners' knowledge. We will secondly use the result to search for diversity among the learners' knowledge in the different schools. We cannot assume that our result tells us how the situation is all over South Africa. It can only give us a clue to the trend among the learners in Grade 10, Port Elizabeth area, Eastern Cape.

6.2.1. Implementation

Before we visited the schools a doctor at the university in Port Elizabeth, who educates future teachers in English as a second language, helped with translating the questionnaire to "easy English", making the learners who have English as a second language understand the questions.

At each of the five different school-visits we tried to follow a fixed schedule. Our first day in each school was aiming to observe how that specific school functioned and get to know the staff and learners. We also prepared the participant teacher for the interviews that we were going to do during the third (in some schools, second) day of our visit. During our second day in the schools we handed out the questionnaire. The learners answered the questionnaire in the classroom during one lesson. Before we handed out the questionnaire we had a short presentation of ourselves and the aim of our study. We also informed the learners that the questionnaire is not a test, and that they were anonymous. We also asked them to answer the

questions individually and as truthfully as possible. We stayed in the classroom during the time the learners answered the questionnaire to answer contingent questions. We brought all the questionnaires out of school when we were finished for the day.

We compiled the questionnaire the same day to get information about the learners and prepare ourselves for the interview that usually took place during the third day of our school visit. All interviews took place some time during the school day and we asked for the possibility to do them in a private and calm area.

6.2.2. Drop outs

It is remarkable that no learners were absent in any of the five groups we visited. Furthermore all learners did participate when we handed out our questionnaire. No questionnaire has been excluded from the study.

6.3. Reliability

Good reliability means that measurements are made correctly. Studies have to be based on a representative selection of participants to avoid that coincidences are affecting the result (Thurén, 1991).

We designed the questionnaire ourselves even though it is based on a questionnaire used in earlier studies (Andersson, 2001). We modified the questionnaire to suit our study, which should increase the reliability. We also adjusted the language in the questionnaire to fit the learners and to avoid misunderstandings.

According to Trost (2001) a study is showing good reliability when it can be remade later on and still end up with the same result. Our opinion is that good reliability is achieved when the presumptions are the same in a repeated study. We think it could be difficult to achieve the same result later again because it would mean involving new persons and society might change. We think that good reliability means that you can pick up changes even though the presumptions are not the same. Looking back on our way to sample material we believe that our study can be remade and consequently achieve a result comparable to ours.

Despite this, we cannot escape from the fact that our observations are personal and affected by our own knowledge and experiences. You need to keep in mind that our image of the school situation is not necessary the same as someone else is. On the other hand the reliability may increase because we are two persons observing. We perceive different things during the observations and through discussions we may combine each other's experiences, making the observed situation more understandable.

We also believe that the reliability increases by using two approaches: qualitative by interviews and observations and quantitative by questionnaire approach.

6.4. Validity

You achieve good validity if you have studied the phenomenon you intended and not something else. It does not matter how good and accurate your measurements are, the study is useless if the validity is non-existent (Thurén, 1991).

The validity of our questionnaire increases by the fact that it has been used earlier on Swedish learners and that we received help with the translation to English. We also made the validity stronger by being present in the classroom, adapting our questions to the context, answering questions on the questionnaire and motivating the learners to participate.

There are some things that could have decreased the validity if we had not been aware of them:

1. Question 5 Part II Questionnaire

In the beginning we formulated the questions in the questionnaire in Swedish. We had to translate the questions to comprehensible English for the learners. A doctor at the NMMU, who is teaching English as a second language, helped us. The problem, as we can see afterwards, is that he was not familiar with these kinds of scientific conceptions. It can also be a result of us lacking the capacity to tell him exactly what we were looking for. After we had handed out the questionnaire in the two first schools, we realized that to one question we did not get the answer we were looking for, because it was vaguely formulated. We later excluded this question in our result to increase the validity of the questionnaire as a whole.

2. Teacher interview 3

Even though we were properly introduced, the teacher did not want to give us her real name and age during the recorded interview. She also told us things during the interview that we are kind of skeptical to believe (see Result from school 3 - Comuxolo). Her desire to remain anonymous may be a result of insecurity of her own knowledge and the unfamiliar situation.

3. Learner Interview 4

At the fourth school (Dale High) we asked the teacher if she could pick two learners that we could interview. During the interview we were told that these two learners were supposed to take part in a debate about global warming and were really informed about the topic. This interview will not help us in our study, because the learners are not representative of all learners in that specific school.

6.5. Ethical considerations

When NMMU booked our visits, our contacts at the schools were informed about our research. The principal, teachers and learners were from the time of our arrival informed about the aim of our study. The participants are anonymous and were informed about their free choice to participate and that they could interrupt and ask questions, during the questionnaire and the interviews, whenever they wanted to.

6.5.1. Impediments

One of the most important things we need to keep in mind is the language difficulty. Just like many of the participants in our study, we only have English as a second language. This may have resulted in some misunderstandings in the questionnaire and during the interviews.

In many interview situations there was a need to be flexible. The meetings were many times interrupted because they sometimes took place in an area were other people tended to be. All kinds of things can affect an interview situation. As interviewers we have to be flexible, patient and persistent to get the material we are looking for to do our study.

You should also consider the rate of motivation among the participants. Because they did not know us so well, lack of motivation may have affected the result negatively. We tried to avoid this by introducing the aim of the study and ourselves.

6.5.2. Limitation

1. Choice of schools

We are really happy to have the contacts we have in Port Elizabeth. One negative thing is that we did not have the chance to choose the schools on our own. Staff members at NMMU, Nelson Mandela Metropolitan University, helped us with the contacts and the visits.

2. Time limit

We only visited the schools for 2 to 3 days. That may seem a short time, but we did have enough time to make observations, hand out the questionnaire and do the interviews.

7. Result

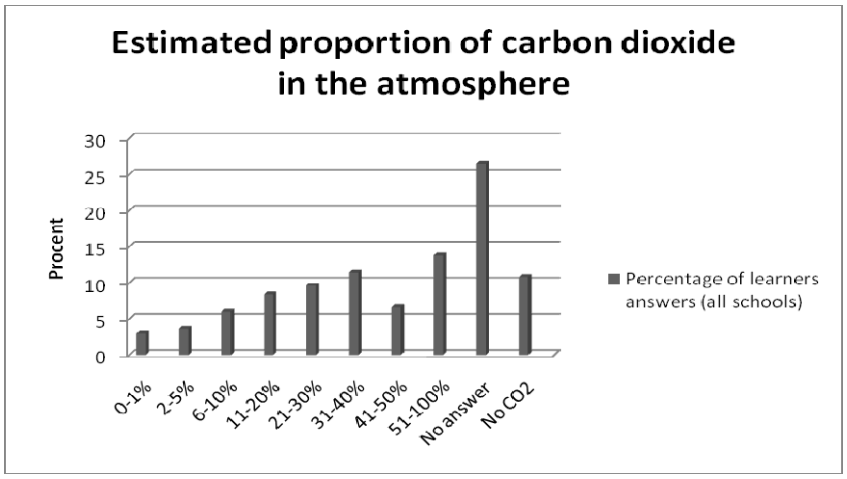
The result from our study will first be presented aggregating all schools. We do this to give an overall picture of the knowledge among the learners. Thereafter we present a comparison of the knowledge in the different schools where we collected our material.

7.1. All schools

A major proportion (84%) of the learners state that carbon dioxide is one of the most common gases in the atmosphere. A tendency is that the learners believe that the air they breathe are composed mostly by carbon dioxide and oxygen (72%). Relatively few (51%) state that nitrogen is part of our atmosphere. Other gases mentioned were hydrogen, ozone, water, methane and CFC´s.

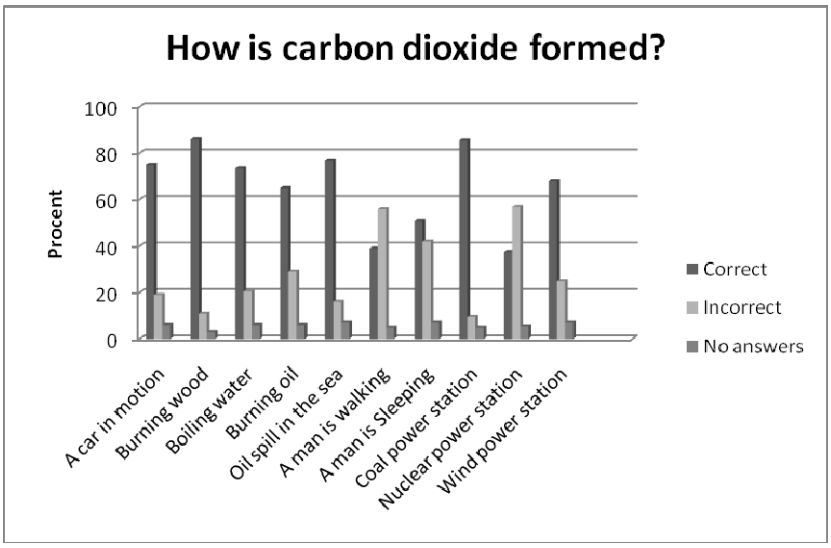
Those learners who stated carbon dioxide as one of the most common gases in our atmosphere are showing a lack of knowledge when it comes to how large the proportion of the gas it is in the air. As we mentioned earlier in this paper the proportion of carbon dioxide in the atmosphere is about 0,038%. Graph 1 shows us that only a few percent of the learners are stating an answer that we could consider acceptable (between 0-1 percent). What is remarkable is that some learners believe that the air we breathe consists of 80-90 percent carbon dioxide.

The “No answer” category involves answers that were confusing, incomplete or left blank. The high percentage of “No answers” indicates that the learners find the question difficult. The category with “No CO_2” is complete answers, albeit did not include carbon dioxide at all.



Graph 1: Learners misconceptions concerning the proportion of carbon dioxide in the atmosphere

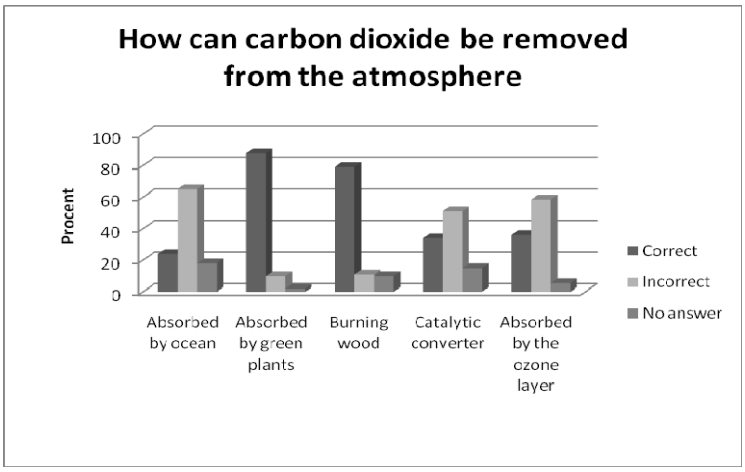
Graph 2 shows that most of the learners know that carbon dioxide is formed when you are driving a car, burning wood, burning oil or producing electricity in a coal power station. They also seem to know that boiling water or oil spill in the sea is not contributing to the formation of carbon dioxide. On the other hand, the learners are showing a lack of knowledge about human respiration ("A man is walking" and "A man is sleeping") and nuclear power station related to carbon dioxide.



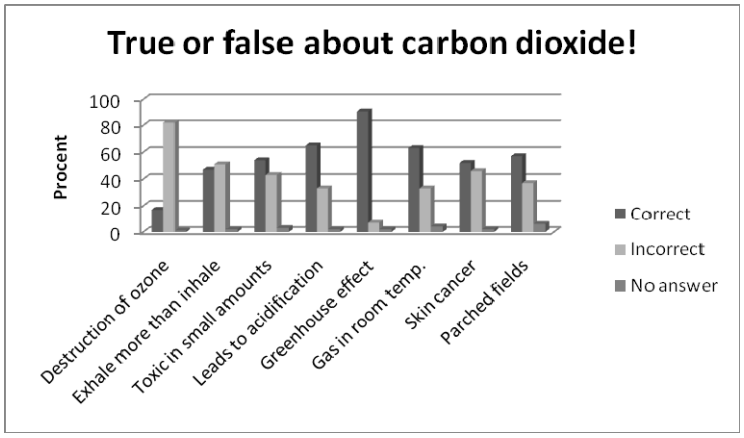
Graph 2: How is carbon dioxide formed?

In the graph below we can see that the majority of the learners seem to know that carbon dioxide is absorbed by green plants and that burning wood is not contributing to any removing of carbon dioxide from the atmosphere. However, some of the learners do not have the correct knowledge about the purifying made by catalytic converters and the fact that the ocean absorbs carbon dioxide. We can also see that the learners have misconceptions concerning carbon dioxide and the ozone layer (graph 3). These misconceptions are clear when we look at the question "true or false about carbon dioxide" in graph 4, further down. More than 80% of the learners inaccurately believe that carbon dioxide results in the destruction of the ozone layer. Furthermore about one out of two learners states that we exhale more carbon dioxide than we inhale and more than half of the learners believe that carbon dioxide increases the risk of skin cancer. On the other hand 91% of the learners are making the correct linking between carbon dioxide and the greenhouse effect.

Despite the high rate of learners linking carbon dioxide to the destruction of ozone layer and an increased risk of skin cancer (graph 4) the general opinion is that carbon dioxide is essential in our nature (89%).

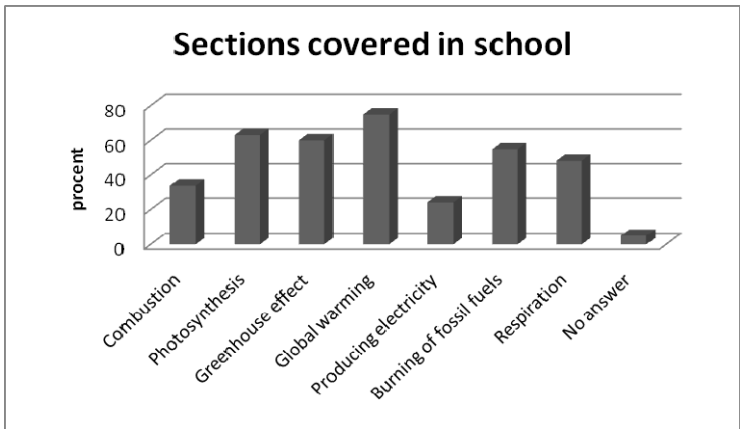


Graph 3: How carbon dioxide is removed from the atmosphere



Graph 4: Examine the following statements relative to carbon dioxide and say whether they are either true or false.

Graph 5 shows that three out of four learners state that carbon dioxide and its role in nature were covered in the section global warming in school. On the other hand it appeared as if carbon dioxide is not discussed just as often during other sections such as producing electricity and combustion.



Graph 5: In which sections covered by your teacher were carbon dioxide and its role in nature discussed?

The learners' different explanations of the greenhouse effect are many and varied. We have decided to sort out the explanations in 3 categories: Incorrect, OK and correct.

- Incorrect – The learner has obvious misconceptions concerning the greenhouse effect
- OK- The learner has a good idea of what the greenhouse effect is but they still showing some lack of knowledge in their explanations.
- Correct – The learner is explaining the greenhouse effect in a correct and scientific way.

Example of explanations that we sorted in under the incorrect category:

"The greenhouse effect is how all these gases (formed by humans) is destroying the world. This will lead to loss of air…"

"When there is more carbon dioxide in the earths atmosphere than oxygen... So greenhouse effect is when the rays of the sun gets blocked in the ozone layer because of carbon dioxide..."

"When plants grow in unnatural conditions but were put there by making them grow all over so we don't be flowerless."

Example of explanations that we sorted in under the OK category:

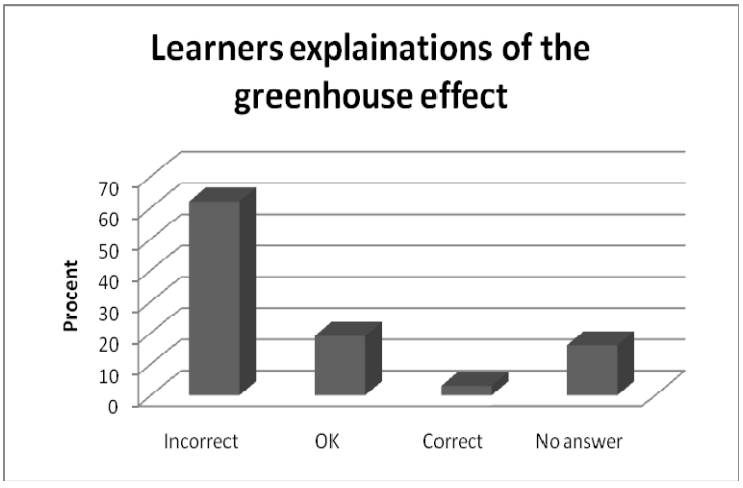
"When carbon dioxide forms a layer in the atmosphere and it traps in heat and doesn't release it off the earth. Causing the earth to heat up and cause the ice in the world to melt making more water in the ocean."

"It is the heating of the atmosphere. It is caused by releasing of greenhouse gases such as carbon dioxide into the atmosphere. It is also the main cause of global warming."

Example of explanations that we sorted in under the correct category:

***"**It is when bad gases trap infrared rays in the atmosphere and they heat up the earth, similar to what happens in a greenhouse. (Greenhouse gases are those bad gases)."*

Graph 6 shows us the result of the learners' explanations.



Graph 6: How would you explain the greenhouse effect to a friend?

7.2. The individual schools

We have numbered the schools from one to five in the order we have been visiting them. We have also given the schools fictional names. The numbers do not have anything to do with social, economic or other society factors like status or reputation. The information about the schools comes from their websites, information booklets, observations and conversations with learners, teachers or other staff. The school names presented in this study are fictitious.

7.2.1. School 1 - Aberdale

The first school we visited is a governmental high school that houses about 700 learners. The school fee is R900 per month or R10 000 per year. [5] The school is located in an ”upper-class area” with mostly white people with high socio-economic background. Most learners come from the upper class, but 10-20 percent of learners have other backgrounds and different a mother tongue than English. All teachers in the school are white and speak either English or Afrikaans. There are variations in the numbers of learners in the classes, depending on directionality it is between 25 to 50 learners in each class.

The impression we get is that Aberdale is a strict, conservative school where the head master and the deputy principal are deciding and taking all decisions concerning the school. The discipline among the learners is really high. Each year prefects are elected from the 12th grade. They have been assigned to create order among the other learners. These prefects are standing in the corridor with their arms crossed watching over the younger learners. To become elected as a prefect you have to be the best in your class in some subject and be good in sports.

The head master is lecturing and informing the teachers at the staff meeting every morning. The whole school atmosphere is permeated by an ambition to be a top-level school, whether it is in education or sports. The teachers and pupils are strictly held in an order that has been implemented in the school for years.

There are 7 lessons each day and when the bell goes off all learners have 3 minutes to get to the next class. The teachers have their own classroom and the learners are moving between the different classrooms. Every Monday and Thursday morning they have an assembly in the assembly room; here the learners are split into boys and girls and by age. The learners sing the school hymn when the principal and teachers walk in and take their seats on the stage in front of the learners. They sing psalms; get hailed for their results in competitions and matches. The principal, once again, will lecture them to work hard and be disciplined.

After school all learners do sports. They have to choose two winter and two summer sports. This school is privileged to have their own sports field in the school area

Results school 1- Aberdale

The 10th grade of Aberdale consists of 39 learners, 16 females and 23 males. The age range is between 15-17 years even though the majority is 15-16 years old. Most of the learners (95%)

[5] 1 ZAR = 0,82 SEK (16 January, 2008)

are born in South Africa and have English as their mother tongue (86%). The rest of the learners have Xhosa, Afrikaans and Portuguese as mother tongues. 70% live with both of their parents and 30 % live with just their mother. Furthermore most of the learners live with one or two siblings (79%). Almost every one of the learners is going to school by car even though a large number of the learners live within a 5 km area from school. Notable is that only one learner reports that he walks to school. The learners state that they mostly get their latest news through TV. Half of them are watching TV 2-3 hours per day.

Almost all of the learners state that carbon dioxide (92%) and oxygen (90%) are compounds in our atmosphere, almost 60% state nitrogen. Other answers are hydrogen, helium and nitrate. It is remarkable that 10% of the learners state that carbon dioxide is the only compound the atmosphere consists of.

The learners at Aberdale have a lot of misconceptions regarding the proportion of carbon dioxide in the air (graph 7, attachment). Notable is also the high rate of blank answers, which probably is a result of their lack of knowledge, or the fact that they feel the question is difficult. Furthermore most of them know that carbon dioxide is formed when you are driving a car, burning wood and oil or producing electricity in a coal power station. They also seem to know that boiling water or oil spill in the sea is not contributing to the formation of carbon dioxide. On the other hand, they are showing a lack of knowledge about human respiration and nuclear power station related to carbon dioxide (graph 8, attachment).

The majority of the learners seem to know that carbon dioxide is absorbed by green plants and that burning wood is not contributing to any removing of carbon dioxide from the atmosphere. However, some of the learners do not have the correct knowledge about catalytic converters or the ozone layer. A rather high number of learners (80%) do not know that the ocean absorbs carbon dioxide (graph 9, attachment).

We also see some lack of knowledge about exhale and inhale. On the other hand, we see that the learners are showing correct knowledge about the carbon dioxide impact on the greenhouse effect (graph 10, attachment). Notable is that fewer of them are linking education in production of electricity and carbon dioxide (graph 11, attachment)

We are able to see distinct misconceptions, both in the questionnaire results (graph 12, attachment) and the interviews, concerning carbon dioxide and the ozone layer among the learners. In their explanations of the greenhouse effect and global warming they are showing us their thoughts regarding the phenomenon

"- It is like because of all the… gas and fuels and everything that is going up in the air.
- And it destroys the ozone layer
- Ja. It is all going up in to the air. And it is creating like a blanket over the earth. So when the sun shines down on to the earth, then the rays always can get back up. But there is no…
They are covered. So the rays are stocked. And it keeps and makes obviously hotter."

Learner 1 and 2, Aberdale

The learners continue the interviews by explaining their beliefs about the greenhouse effect and global warming

"-And also like... also forms like the depletion of the polar ice caps on either side of the earth.
-Making them melt.
-Making them melt. And that makes like a less safe environment for the animals and things like natural habitat of it. Also different plants and in different parts…

- …A lot of them die out because they can't....
- Extinction of some things…
- As well as animals. Because animals now have to adapt differently and a lot of them can't."

Learner 1 and 2, Aberdale

The learners also told us about their negative attitude to the government and that the differences in their society create conflicts between different races and cultures. They further described how people without money and houses are forced to live in squatter camps. The learners told us stories about violence and crimes that are part of many peoples day-to-day life in South Africa.

"All over the Global Warming affects food, which affects poverty, which affects… It's like a chain reaction and unfortunately… we still, like, trying to rebuild ourselves. So it hits people quite hard here."

Learner 1, Aberdale

The teacher that teaches the 10th grade at Aberdale was giving us a correct definition of both the greenhouse effect and global warming during our interview. He also showed us awareness of the learners' misconceptions concerning the greenhouse effect and the depletion of the ozone layer. And he thinks that pollution plays a big role in both of them, which tends to lead learners mixing them up. Another thing he has to deal with is that the learners think that the global warming is something that is going to happen overnight, even though it is a gradual thing. He is also aware of the possible difficulties that learners with another mother tongue could struggle with.

"A lot of them in this area come from Xhosa background. A lot of them, you can say, have disadvantage backgrounds. And so they don't always understand and those are the ones that usually confuse the issues. And they often don't understand the concept because they don't grasp the language used about it."

Teacher 1, Aberdale

Furthermore he tells us that learners today get more information, knowledge and awareness through their access to technology. He also tells us that this particular issue is most sincerely discussed in media and politics and that the media blame global warming for the experienced change in climate, such as more rain and colder winters, in South Africa. He also adds that we, from the physical point of view, cannot say that global warming is exactly true, so we have to take the scientists word for it.

The teacher tells us that the most important thing the learners need to know about the greenhouse effect and global warming is that they themselves are contributing to it. During our interview with the learners we could see that they are aware of their impact on the environment. They also possess knowledge about what they can do to prevent an increasing temperature on earth. They find wastage and littering a big issue, and they think that a solution to the problem is to create more awareness in society. They also tell us that many people in South Africa do not have the opportunity to prevent the global warming in the way that they would like and that it is not implemented in their society like it is in more developed countries. The people have other huge social concerns to deal with first.

The interviewed learners at Aberdale told us how they believe global warming will affect people in South Africa.

"- It going to get very hot. And then… is going to get… I mean as you know, it's hot already and already we having food – shortages and stuff. Imagine…how you know how bad ones plants and things are dying.
- I think it could affect people and animals and things like that… Maybe not the land, because I think the land can like…
- I think our land will be okay, you know
- Ja. But I think the poverty and things will rise definitely. And like our government always been saying " Ja. We going to build houses" and things like that, but things then never happen.
- It doesn't.
- Like after apartheid happened and stuff...That was the government's slogan that was their thing. "We are going to provide it to our people". And it has never happened."

Learner 1 and 2, Aberdale

7.2.2. School 2 – Belveder

The second school we visited is a private school, a former white private school, located about one hour drive outside Port Elizabeth. The school and the beautiful piece of land that is included lie on a large property owned by a trust. The founders started the Preparatory School back in 1936, and it was privately owned until 1957. In 1966 there was a need to develop a senior school, because some of the parents, who were also teachers, were having difficulty in placing their children in private schools for older learners. That year the college was funded. At first the school was only for boys, but because some members of the staff had daughters, girls were accepted in the 1970's. On the property there is a preschool and a high school college. In the 1990's the school introduced a day scholars' option and today almost 300 of the 750 learners travel to and from school every day. The rest of the learners are boarders, who stay in hostels near the school. They only travel home to their parents during the long holidays. Nowadays the school has learners, mostly white, from all over South Africa and also from other countries like Namibia, Zimbabwe, Zambia, Germany, Botswana, England, Scotland, etc.

The college, where our visit took place, has 350 learners and the staff, teachers and headmaster, is composed of 33 people. The school fee for day scholars is 40 815 rand and for boarders it is 66 060 rand per year, excluding school uniform and books. The school fee enables a high standard of premises and equipment. But the high school fee also comes with high expectations from the paying parents and both teachers and learners hold a pressure to perform good results.

Most teachers live on the property and they are dedicating their life to the school and the learners. Working, as a teacher here is not only a job, it is a life passion and a lifestyle for these teachers. As a working teacher you will get free accommodation and meals for you and your family. Children in the family attend the school free of charge. The longer you stay on the school as a teacher the bigger house and the higher salary you will get. During conversations with different teachers we have been told that the waiting list for a teaching job in this school can be as long as 5-10 years and the teachers here are sincerely happy to hold a position at this school. The popularity to work here creates a competitive situation, which results in highly educated and qualified teachers working in the school.

Every school day has 7 lessons and ends with sports. The learners have to choose one summer and one winter sport. Mountain biking, water polo, swimming, rugby, cricket, horse riding, hockey, cliff climbing and surfing are some of the sports that the schools offer the learners to choose from. All sports are performed on a high standard sports field on the school property.

When the teachers sign their contract they are committed to do some activities in the afternoons with the children. Most of the teachers coach one or two groups in some sport. Except from sports it can also be extra math lessons, debate, chess, acting, music, etc. Matches and competitions are performed between schools on the weekends and are big events. Compare to Sweden almost all sports competitions in South Africa are between school teams. The sports clubs are almost a non- existing thing among the youth.

Results school 2 – Belveder

The 10th grade of Belveder consists of 25 learners, 16 females and 9 males. The age range is between 15-17 years; the majority is 15-16 years old. Most of the learners (80%) are born in South Africa and have English as their mother tongue (84%). The rest of them comes from countries like Namibia, Botswana, Zimbabwe and Scotland and have other mother tongues. Almost 70% live with both of their parents, 16% live with just their mother and 12% with just their father. Furthermore the most of the learners have two (48%) siblings. They report that they mostly get their latest news through friends (44%) and TV (28%). About 60% of the learners are watching TV 0-1 hours per day. No learner reports that she/he is watching TV more than 3 hours a day.

24 out of 25 learners state correctly that nitrogen is one of the most common gases in the atmosphere. They also seem familiar with the fact that the air we breathe consist of oxygen (88%) and carbon dioxide (76%). Remarkable is that a relatively high rate (48%) of them also claim that hydrogen is one of the most frequent gases in the atmosphere.

Two learners are showing correct results with regard to the proportion of carbon dioxide in the atmosphere. 10 out of 25 claim that the air consists of 6-40% carbon dioxide, two learners state that the proportion is 51% or above and 24% chose not to answer the question (graph 13, attachment).

The learners in grade 10 are showing good results regarding the fact that carbon dioxide forms when wood burns, during human respiration (“a man is walking” and “a man is sleeping”) and by using a coal power station to produce electricity. They are also aware that carbon dioxide is not formed when water is boiling, by oil spill in the sea or by using wind power station to produce electricity. Notable is that 40% do not know that carbon dioxide is formed when a car is running and only half of the learners know that carbon dioxide is formed when oil is burning. 40% of them also believe that carbon dioxide is formed by using a nuclear power station to produce electricity (graph 14, attachment).

All learners know that plants are using carbon dioxide in their photosynthesis and that this results in a removal of carbon dioxide from the atmosphere. They also seem to know that burning wood is not contributing to any removal of carbon dioxide. But according to the questionnaire they show a lack of knowledge of the function of catalytic converters and also of the fact that the ocean absorbs carbon dioxide. In addition we see a false belief that the ozone layer should have an impact on the rate of carbon dioxide in the atmosphere (graph 15, attachment). The confusion concerning global warming and the ozone layer is obvious from the results that carbon dioxide also destructs the ozone layer.

It is remarkable that 72% of the learners state that we inhale more carbon dioxide than we exhale even though 1 out of 3 claims that carbon dioxide is toxic for humans in small amounts. One third believe that carbon dioxide increases the risk of skin cancer and the same

rate of learners also think that carbon dioxide leads to parched fields. More than 60% know that carbon dioxide leads to acidification of land and lakes (graph 16, attachment).

Most of the learners state that carbon dioxide is essential in nature and that its role in nature has been discussed during classes of global warming, the greenhouse effect, photosynthesis, respiration and the burning of fossil fuels. Fewer of them report that the role of carbon dioxide was covered in the section of combustion and only 24% make the linkage between carbon dioxide and the "producing of electricity" as a section covered in school (graph 17, attachment). Even though only 12 % of the learners correctly can explain the greenhouse effect it is still the highest percentage among the schools in this study. Furthermore almost 30% in grade 10 state an "OK" explanation (graph 18, attachment).

"I would say it is the amount of carbon dioxide that are released into the atmosphere and this is making a blanket around the earth and eventually sunlight wouldn't be able to come into the Earth and there will just be sunlight trapped inside."

Learner 3, Belveder

On the question of the difference between the greenhouse effect and global warming the learner states:

" Global warming is more the way that the ice caps are melting and the temperature is increasing more and all that stuff."

Learner 3, Belveder

A few times during the interview the learners are referring to "An Inconvenient Truth" with Al Gore. They are aware of the causes of global warming and what they can do to prevent. They also think that there are big differences in knowledge about these phenomena outside school. They think we need to learn to be more aware about them.

According to their teacher the learners today know much more about both the greenhouse effect and global warming than they did 10 years ago. The teacher thinks it is because of the latest changes in the syllabus. She also believes that the most important thing the learners need to know is that human activities are changing the nature of the atmosphere to the extent that it affects other living creatures.

The teacher has not noticed any particular misunderstandings concerning global warming that are the result of language problems but she says that she is aware of the issue because the school gets boarders from many different countries. These learners know the facts but need to learn the vocabulary in English. Instead she finds problems when the learners get confused about the different chemicals and their causes.

"- Are there any difficulties to teach the students about this?
- No. I mean in general the kids tend to get confused between what causes acid rain, what causes the ozone layer to become depleted and what causes Global Warming. So they get… especially for us in biology and geography, the pupils don't have to have done chemistry. So for them, when you talk about molecules and when you talk about, you know, molecule combining with water in the atmosphere to form an acid, it's actually that they don't really know what you're talking about. If they don't do science... So those who do science, they're fine. The ones who don't do science, they can sometimes become a bit lost. And then they will get confused between the different types of air pollution. What the causes are and what the consequences are. So that would be my problem. I have to make sure that they can distinguish between the different kinds of air pollution."

Teacher 2, Belveder

When we ask the teacher how she thinks global warming will affect South Africa in the future, she answers by saying that she can only refer to what the media and science are predicting. She tells us that there are and will be more changes in temperature and precipitation, the seasons will get mixed up and people along the coast will be affected. She describes the situation in the cities as high on crime and there is a migration to the coastal areas because the people want to feel safe. In 40 years more people will live by the coast and be affected by the environmental changes. The poor people will suffer even more because of diseases and lack of food.

7.2.3. School 3 - Comuxolo

The school is located in the northern part of the city and it is what South African people will call ”a black township school”. The school only has 43 teachers (20 women and 13 men) and over 1000 learners. All teachers and learners are black. The most common mother tongue is Xhosa and the learners come from quite rough backgrounds and many of them live in squatter camps/townships. Even though it is a governmental school they have to pay a school fee to go there. It is R150 per year and many of the learners' families struggle to pay. According to the principal these payments will cover water and electricity in the school.

Our first impression is that the school is in bad shape and in desperate need of renovation. The buildings are dirty and scribbled and almost every window is broken. During a conversation a teacher tells us that the learners during wintertime have to wear jackets inside so they do not get to cold. The learners are sitting in really old benches that look as if they are going to collapse any second. In large classes the learners have to share benches and chairs because there is not enough for all of them. Mostly there are 30 to 50 learners in each class. In grade 10 each class only has one textbook per subject and it is often used.

Every Monday, Wednesday and Friday start with an assembly, where the learners are standing arranged in their classes in the schoolyard. They sing psalms and pray before the principal gives information and talks about the happenings of the day. The learners have 7 lessons a day, and all classes have their own classroom. At this school it is the teachers who are changing classes for every new lesson. The teachers never carry their material to class; there is always a learner who meets the teacher before class to carry books. In each class they also have one learner in charge of wiping the black board. As soon as the teacher filled the board she nods at the learner who directly wipes out the notes.

They have one break a day, like a lunch break for 45 minutes. During lunch break learners run errands such as buying fruit and snacks for the teachers. The learners do not have any sports in the afternoons and we did not see anything that indicated any sports activities.

The school atmosphere was calm and not stressed. It was rather common that the teachers ended the lessons before or after the set time. The principal did not so strictly hold the teachers and they were deciding themselves what they were doing during their work time. During our visit we found a lot of classes without a teacher so the learners were doing schoolwork themselves in the classroom. The teaching was very conservative and based on the learner memorizing what the teacher said. The whole class repeated in choir every word after the teacher. When the teacher gave the learner permission to speak, they had to stand up and when a learner answered incorrectly the punishment was to remain standing. Sometimes they got a second chance later on and sometimes they just remained standing for the rest of

the lesson. The learner influence was non-existing and the teacher's knowledge is not questioned.

Results school 3 - Comuxolo

The 10th grade of Comuxolo consists of 36 learners, 23 females and 13 males. The age range is between 14-18 years old, the majority is 15-16 years old. Most of the learners (94%) are born in South Africa and have Xhosa as their mother tongue (92%). The learners mostly live with both of their parents (42%) but there is a high rate of them living with only their mother (31 %) or other relatives (25%). This school is also the only one in our study where learners report that they are living alone with their siblings. Two out of three report that they live with 3-5 siblings. Most of them live within a 20 km range from school and walk to school.

The learners at Comuxolo have a high frequency when it comes to watching TV. Most of them are watching TV between 2-3 hours a day. 17% of them report that they are watching TV between 4-5 hours a day and 14% report that they are watching TV more than 5 hours a day which explains the result, that more than one out of two learners (56%) mostly get the latest news through TV.

Almost 80% of the learners report that carbon dioxide is one of the compounds in the atmosphere. Nearly half state oxygen and 39% state nitrogen. But they also show us their belief that the atmosphere consists of ozone, CFC´s and air pollution. Half of the learners leave blank answers to the question of the gases' proportion in the atmosphere, 17% state that the proportion of carbon dioxide in the atmosphere is between 31-50%, and 14% think the carbon dioxide proportion is between 51-100% (graph 19, attachment)

The learners know that carbon dioxide is formed when a car is in motion, wood is burning and when a coal power station is producing electricity. On the other hand they are showing a lack of knowledge when it comes to respiration, burning of oil, and nuclear- and wind power station producing electricity**.** Notable is also the result that 36% think that carbon dioxide is formed when water is boiling (graph 20, attachment).

They seem aware of the fact that green plants are absorbing carbon dioxide and half of the learners also know that the ocean absorbs carbon dioxide. Almost all learners also know that carbon dioxide is contributing to the greenhouse effect. On the other hand we see distinct misconceptions regarding carbon dioxide and its relationship with the ozone layer, 89% of them believe that the ozone layer removes carbon dioxide from the atmosphere (graph 21, attachment). Nearly 92% state that carbon dioxide destroys the ozone layer and 72% think that carbon dioxide increases the risk of skin cancer (graph 22, attachment).

The misconceptions we can see in our questionnaire are enhanced in the interview with the learners. They mix up all factors related to environmental issues like the greenhouse effect, global warming, ozone depletion, skin cancer, CFC´s, and pollution. They are very aware of that human activities like industries, burning of fossil fuels and driving cars are contributing to global warming. They also think that a solution to the problem could be to establish a permission that people and industries have to pay for their exhaust, like a penalty. They also believe that education is another solution:

"…And as well is to teach about the global warming, you can also learn more because there are some people that…they are doing wrong.
-They don't even know what global warming is…."

Learner 5 and 6, Comuxolo

Furthermore the learners tell us that they do not think other people, friends and neighbors know anything about the global warming.

" No. They are not. Because… You can't say no. With the farmers…there is a high rate of food in our country. The farmers… this tough weathers are destroying their food and their merchandise so they wouldn't be able to manufacture and keep transport food properly. Because of this weather conditions and this global warming.
…
They don't know the consequences of the global warming and their act. They are suffering but they don't know that they suffer from this global warming."

Learner 5, Comuxolo

They also inform us that people in their community are uneducated and therefore do not know how to prevent global warming.

During our interview with the teacher we got some interesting answers. On the question of how she explains the greenhouse effect and the global warming she says:

" I just ask them if… In fact I start from where they know. From known to unknown. (X3). I ask them about the gases they know. (X2) So they tell me the gases they know. I ask them which ones do you think are more dangerous to our ozone layer. So they will tell all the answers, all the answers, then I'll start to explain to them, or before I even ask them which ones do you think cause danger of change in our climate. I ask them where or what are the sources of these gases. They must know the sources of the gases. And I tell them that these gases are the ones that are causing the global warming. Gases like CO_2, it's the most popular one. And gases like CFC. So those are the carbon gases that I say they are the most dangerous ones. And where these gases come from, what are the sources, so there is lot of sources of CO^2. In fact…outside what ever you burn, when you breathe out for example CO^2. That's how I explain these gases."

Teacher 3, Comuxolo

She further tells us that these gases are causing the greenhouse effect and global warming and that they prevent the heat from rising and cause dry conditions. And this heat will be trapped in the lower layers of the atmosphere, were it will cause more and more heat until the temperature rises.

The misconceptions among the learners are probably based on the teacher's incorrect facts about global warming. And even though she is the Geography teacher and the schools deputy headmaster, she does not really know which school subjects the greenhouse effect and global warming is discussed in but she thinks it should be in geography.

We asked if she uses any school supplies when she teaches the learners about global warming and the greenhouse effect. She answers:

"*No no no no no no! Sometimes I don't even have a textbook, especially with grade 10. With grade 10 they don't have any textbooks. I use my own knowledge and I get other knowledge from like my university books. Otherwise I don't have any grade 10 textbooks in geography."*

Teacher 3, Comuxolo

During our visit in the Grade 10th classroom we saw a poster about global warming. It was the only thing on the walls and it was made of an A3 paper with newspaper cuts. The poster

was full of incorrect facts and misleading information. During the interview we asked the teacher if she noticed any misunderstandings among the learners about to global warming.

"No nothing! There is no…Nothing! They do understand it. They like it! Did you see my picture there in grade 10? They like it! I never said to them they must come up with that poster. They did it themselves. Then they came to me and said, " Have you seen our poster?" It was already there. So they do enjoy it"

Teacher 3, Comuxolo

The teacher tells us that global warming is a current issue and a relatively new topic for the learners. She also says that she thinks there will be changes in the environment, in the weather patterns and in the seasons due to global warming. It will become colder and hotter, droughts and there will be more rain, diseases and skin cancer, she says.

7.2.4. School 4 – Dale High

This school is located in rough neighborhoods not far from school 3. This school has only colored learners and colored staff. The school has over 1400 learners and 47 teachers, almost half of them are men and the rest are women. The classes are large, around 30 to 55 learners in each class. The school fee is R950 per year and many families are struggling to pay it. The learners have seven lessons a day and two short breaks. Two days a week they have assembly during the first period. All learners are standing in line according to grade and the principal is speaking. The classrooms we had the opportunity to see was quite well equipped relative to the level of the school fee, but the learners did not have textbooks. There were a lot of articles from newspapers on the walls and most of the education was based on the articles and the teacher's own books.

The area around this school is rough. Drugs, prostitution and criminality are common things in these blocks where almost all the learners come from. There are fences around the school area and there are also guards that are watching the entrances and cars. There are also bars outside the windows and barbed wire along the walls. The first thing we saw when we left the car in the morning was something that looked like gunshot holes in one of the windows. During a conversation with a man at the university we were informed that different gangs are ruling the area and earlier also the school. But the new headmaster has made peace with the gang and nowadays the school is left alone. In the headmaster's office a note with a direct number to a certain contact in the police is hanging on the wall.

Results school 4 – Dale High

The 10th grade of School 4 consists of 38 learners, 29 females and 9 males. The age range is between 16-19 years old, the majority is 16 years old. All the learners are born in South Africa and most of them have English as their mother tongue (71%), other mother tongues are Xhosa and Afrikaans. They mostly live with both of their parents (55 %) but there is a high rate of them living with only their mother (29 %). Half of the learners report that they are living with 2 siblings. Most of them live within a 10 km range from school and go to school by car or walking.

A high number of learners in school 4 state carbon dioxide (89%), oxygen (79%) and nitrogen (53%) as the most common gases in our atmosphere. All of them believe that the proportion

of carbon dioxide in the atmosphere is higher than 6%. The other answers are equally shared between all the categories from 6-10% to 51-100% (graph 25, attachment).

A majority of the learners know that carbon dioxide is formed when a car is running, wood and oil is burning and a coal power station is used to produce electricity. They are also aware that oil spill in the ocean is not forming any carbon dioxide. Almost one third of the learners believe that boiling water contributes to an increased proportion of carbon dioxide and the learners are showing a lack of knowledge concerning the role of human respiration. We also see that they think that producing electricity by nuclear-, and wind-power stations is forming carbon dioxide (graph 26, attachment).

Most of the learners state that plants are absorbing carbon dioxide, 37% also state that oceans are responsible for removal of carbon dioxide from the atmosphere. Almost 70% think that a catalytic converter is removing carbon dioxide and half of them think that the ozone layer is contributing to a loss of carbon dioxide (graph 27, attachment).

Almost all learners know that carbon dioxide is contributing to the greenhouse effect. They are also aware of the fact that carbon dioxide is a gas in room temperature and that it is not increasing the risk of skin cancer. On the other hand more than half of the learners believe that carbon dioxide is toxic in small amounts and that we inhale more carbon dioxide than we exhale. There are also almost 70% who believe that carbon dioxide is destroying the ozone layer (graph 28, attachment).

Many learners state that carbon dioxide is discussed in the sections of global warming, greenhouse effect, photosynthesis and burning of fossil fuels. Half of the learners state the section of respiration and a few learners state combustion and producing of electricity (graph 29, attachment).

During our interview with the learners, we were kind of surprised by their use of advanced terms when they answered our questions and explained global warming:

"-Certain like factories or like basically human beings, they pollute the air, right. So a thick layer of greenhouse gases, like CO^2 and methane, all of those they block of… actually, this radiation that comes from the sun just being blocked in the atmosphere so it can't escape, it increases the…
-… Temperature.
-Things like the ice capes melting and things like that"

Learner 8 and 7, Dale High

After the interview, the learners told us that they are supposed to participate in a debate on global warming in just a few weeks. This can explain the more advanced terms they are using. To the question on what they think is the main reason for global warming, they answer:

"*- Air pollution!*
- Air pollution... and deodorant sprays.
-... Aerosols, yes
- Yes, aerosols"

Learner 8 and 7, Dale High

These are the first learners that mention aerosols in our study. Even though they are aware of the fact that aerosols are affecting the climate, they are misinformed about how. Aerosols have a cooling effect on the climate and are in fact contributing to a decreasing temperature on earth.

The learners also tell us that people in their neighborhood do not know much about global warming, because they are not informed about it. Furthermore neither of the two learners think that they, as a person, do anything that increases global warming in their day-to-day life? But they have an idea of how they can prevent it.

" Yes, actually... instead of using, like… I don't know, it is probably going to be more expensive, but instead of using normal cars or if, in certain circumstances, you have to use a car, and there is like more than one person that is going to that same area that you are going to. And then you can… car pools, you can do that. And with the new technology, the hybrids and those cars... you can also use them. But also you can recycle the waste in your house, like maybe the apples you can… the waste products… like all of the apple you can use it… produce ethanol and then use that as biofuel instead of using, you know, crops…. Organic waste."

Learner 8, Dale High

During the interview with a really stressed Geography teacher, he describes how he explains the greenhouse effect and global warming to the learners:

"I use an example of a car or blanket. The more blankets you put on, the warmer you get. So the blanket is your gas, the more gases you have, the warmer it becomes. Or the car as well, a car in a hot day, ok in the summer here, and I have a really good example because one of the University professors in Cape Town Left his baby, on his way to work, he left his baby in the car and forgot about the baby. It's terrible. The baby died…. So I explain what happens in a hot car on a hot day. Those windows… short waves comes easily in and long waves can't get out, so car heats up."

Teacher 4, Dale High

The teacher finds it most important to teach the learners to be aware of the fact that global warming is happening. He further tells us that the biggest problem in teaching about the greenhouse effect or global warming is visualizing. Lack of material such as books, pictures and TV makes it hard for the learners to understand. The teacher tells us that he has the movie "An Inconvenient Truth" on tape, but it is too much work to get the TV into the classroom. He also thinks that access to the media has positive effects on the learners' knowledge about the climate changes. According to the teacher are the learners that watch TV the ones that understand the greenhouse effect and global warming. He tells us that global warming is a recent subject in school but it is not discussed in the media as much as it should be. He thinks they should have more emphasis on the effects and that promoting and publishing the causes of global warming would make more people do things that prevent some of the effects.

The teacher does not think there is any misunderstanding concerning global warming among the learners, except that the facts of effects get mixed up. The textbooks and magazines exaggerate the scenarios for the learners and they get confused. He also does not think that different mother tongues will contribute to misunderstandings or misconceptions. The learners start in this school in Grade 8 and according to the teacher the schools before that make sure that learners understand.

He does not think there are any noticeable effects due to global warming in today's South Africa. He believes however that the coastal areas, agriculture and the rural people will be affected in the future. There will be lack of food and that diseases we thought were extinguished will affect the people.

"But there are this situation were they will. Are effected in per se by planting trees they can do that, which is actually what you can do to them. So you see global warming doesn't reach them in the way the more developed countries are affected. We are affected but mostly we don't see it urban areas. …They are not so concern about

the global warming, as I said before to you, I tell you, they know it but they struggle more to have food on the table to the families."

Teacher 4, Dale High

At the end of our visit he said that the school is an "end-station" for many learners. They do not have the marks that qualify them to the university and they do not get a job because of the high rate of unemployment.

7.2.5. School 5 – Edison High

This rural school is situated in a smaller town located in the middle of an orange plantation district, approximately one and a half hour drive north of Port Elizabeth. The school has only 350 learners in grade 1-12 and there is only one class in each grade. Including the headmaster, 14 paid teachers are teaching. Depending on what subjects the learners choose in Grade 10, 11 and 12, the number of learners in each class can vary from class to class. The school fee is R4200 per year.

The school is located on a huge property on the outskirts of a small and peaceful town. The school property contains a lot of sports fields. All learners, even though it is not compulsory, choose one summer and one winter sport and there are sports practices every afternoon. The teachers are in charge of coaching the after school activities. Both teachers and learners have a lot of school supplies and the whole school is clean and well equipped. This school also has a hotel keeping and catering education.

Almost all teachers and learners are white and Afrikaans speaking, but there are some black learners with Xhosa as their mother tongue. Our experience from this school is that the teachers and learners mostly are speaking Afrikaans during the lessons. This causes difficulties among the learners who are Xhosa speaking; they have three languages to struggle with.

A couple of teachers in this school was open with their racism and believed that black people only mean trouble. During one of this teacher's lesson only white learners were spoken too.

Results school 5 – Edison High

The 10th grade of this school consists of 18 males and 10 females. The age range is 14-17 but the majority is 15 years old. Most of the learners are Afrikaans speaking and have this as their mother tongue (75%); the remaining learners have other mother tongues such as Xhosa, English and Flemish. All learners (except one) are born in South Africa. Many of them live close to school and go to school by car or bus. Only a few of them state that they are walking to school.

A majority of the learners (82%) state that carbon dioxide is a common compound in our atmosphere, 57% states oxygen and only 14% states nitrogen. When it comes to the proportion of carbon dioxide in the air, one third of them believe that it is between 51-100% (graph 31, attachment).

Most of the learners know that carbon dioxide is formed when a car is driving, when wood and oil is burning and coal power stations are used. They are also aware of that boiling water, oil spill in the ocean and the use of wind power stations do are contribute to the forming of

carbon dioxide. However, their lack of knowledge concerning the human respiration ("a man is walking", "a man is sleeping") is showing. We also see that they think that producing electricity by nuclear power stations is forming carbon dioxide (graph 32, attachment).

Even though most of the learners know that plants are absorbing carbon dioxide only 7% states that the ocean absorbs it (graph 33, attachment). We also see obvious misunderstandings regarding the relationship between carbon dioxide and the ozone layer. This also explains that many learners think that carbon dioxide increases the risk of skin cancer.

They are furthermore aware of the fact that carbon dioxide is contributing to the greenhouse effect. It is also notable that the learners in this school have more knowledge about the catalytic converter than the learners in the other schools. Almost 60% of them know that we exhale more carbon dioxide than we inhale during respiration. Only 54% knows that carbon dioxide is a gas in room temperature and just as many believe that it is toxic for humans in small amounts. Nearly 50% also believe that carbon dioxide leads to parched fields (graph 34, attachment).

Like the rest of the schools, these learners state that they are familiar with carbon dioxide from discussing global warming and the burning of fossil fuels in school. On the other hand only a few of them state that the carbon dioxide is discussed in connection with the greenhouse effect, photosyntesis, respiration, combustion and the production of electricity (graph 35, attachment).

This school is showing a lack of knowledge of the greenhouse effect. Only 14% state an explanation that we consider "OK", no learners reported a correct one (graph 36, attachment). This has probably a linkage with the answers above. During our interview with the learners we received following explanation of the greenhouse effect:

"It's the ozone layer on the earth is like a blanket and then the CO_2 gets trapped inside and then it can't escape and then the earth gets hotter and hotter and colder and colder."

Learner 9, Edison High

Despite their obvious misconceptions of the greenhouse effect they still know what causes the increased level of carbon dioxide in the atmosphere and also that the plants use carbon dioxide in their photosynthesis. They further tell us that they think all kinds of pollution are the main reason for the global warming. One of the learners also adds that another contributive reason is that there are not enough plants to fight the pollution. Both learners agree that everyone is responsible for the increased temperature on Earth by driving cars and breathing out carbon dioxide.

Their teacher is well aware of the difficulties the learners struggle with to understand the greenhouse effect and global warming and she also seems anxious that the learners get a good education. The most important thing she thinks the learners need to know about the phenomenon is that they themselves have the possibility to prevent it.

"Because we can't change the world one alone, but I think if everyone alone, go and do their best for that thing. I think we must teach them that. What can they do in their houses and in their homes to change? Stop the pollution and stop waste and all those things. I'll think that's the best part."

Teacher 5, Edison High

She also tells us that it no longer is a problem to teach the learners about the global warming or the greenhouse effect.

"I don't think it's that difficult anymore because they see it on the news and they hear about it on the radio and they read about it. And this movie is about it [An inconvenient Truth, our comment]. So I don't think it is that difficult anymore. But I think some of them don't know what it leads to as well. Because after your questions, yesterday they came and asked me, especially the greenhouse effect, what's the problem with the green house? So the ones that read and listen they will have heard the terms. But some, no, they wouldn't. So it would be difficult for some of them. If they've heard about this before it wouldn't be that bad.

Teacher 5, Edison High

She is also one of the teachers that are aware of the fact that learners with different mother tongue have difficulties understanding and that they are developing misconceptions.

"Yes, they do. Because English in our country is their third language. Especially for the Xhosa people. So it's like the third language for some of them. So it's difficult for them, ja.
They talk so many languages in their homes, different black languages, so English is sometimes second sometimes third. So it is difficult sometimes for them."

Teacher 5, Edison High

She thinks that the ongoing electricity crisis in South Africa have lead to that global warming is a current issue. She tells us that it is a debate going on of whether South Africa should use coal- or nuclear power stations to produce electricity.

"- Yes! Especially with the electricity crisis. You know about our electricity crisis? Ja!
Load shedding and all those things, and the coal burning. So now we talk about the pollution through the coal. What would be better? Nuclear power station or coal power station? So we also talk about that now. So for us, now that is a big discussion in our country."

Teacher 5, Edison High

According to the teacher there are changes in the environment due to the global warming. She tells us that the winters are much colder and the seasons are changing and that this will lead to changes among the animals and plants as well. She has also noticed that it is much dryer than usual and she thinks that this will affect the people badly water-wise. South Africa is not a water-rich county and if it gets dryer there will be no water, she says.

7.3. Observations of Current issues

7.3.1. Load shedding

Load shedding is something that had become a current issue just before we arrived in South Africa. It will affect everyone no matter where you live, in the country. Because of the ongoing electricity crisis, the government had to save electricity so they could sell it to other countries as per contract. Because of this way to handle the problem, the electricity had to be shut off 3-4 hours per day certain time-periods.

7.3.2. Safety and Crimes

We took all chances we had to be up to date with South African society. We watched TV and read newspapers to see what was going on. One thing that hit us the most was the high rate of crime. Every time we opened a newspaper we could see page after page with ads with lost people, mostly young girls. They had been kidnapped. The high rate of crime also made people protect themselves. In rich neighborhoods all houses were surrounded with two-meter walls, electricity fences, alarms and signs with the message “Armed Response”. Safety thinking is a big part of the South Africans’ day-to-day life.

7.3.3. School Supplies

We will not analyze the textbooks in detail, but we had some quick views to look at the chapters that brought up the greenhouse effect and global warming. All schools have the same book and we think there is too little space in it about these issues. At most there are 4-5 pages about pollution. The inequality between the schools when it comes to school supplies is enormous. In the black school we were told that the 10 graders do not even have their own textbook. We did see one but that belonged to the teacher teachers. We could see that many teachers were strictly teaching according to the textbook, even though a lot of learners did not even have one. Some teachers were using other books. These came from their teacher’s education and were not up to date.

8. Discussion

8.1. The Context

"The circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood and assessed." (McKean, 2005)

In this study the context describes where the learners are situated due to education, background, socio-economics, color, class and mother tongue (our addition)."

The definition of context in this study

As we earlier mentioned, Vygotsky discussed that the learners bring their culture into the classroom situation, which affects the learning process. The learners' roles and values are based on previous experiences. Barba (1998) adds that they have already developed a way of learning based on their culture and background when they enter school. She also describes that learners from different cultures may have different ways of knowing and learning. We agree with the two previous writers that the context influences the acquisition of knowledge. In the following section we will try to clarify how this affects the process of learning in the South African society.

8.1.1. Segregation

South Africa is still dealing with its cruel history. A structure based on race has been built up over years of colonialization and apartheid, which has excluded the non-white people of South Africa from many things. In the post-apartheid South Africa there are no laws or rules that justify discrimination or segregation, but the society is still divided. Proclaimed "white", "black" and "colored" areas and schools are contributing to the segregation among the population. Although the government tries to sort out the social barriers, it will take generations to change these opinions that have been implanted over centuries.

The learners told us that the differences in their society create conflicts between different races and cultures. Even though we have not seen any discrimination among the learners, we have seen it among a few older teachers, which have difficulties educating learners from other social groups. The racism in school is something we could write a completely different paper about. So we only choose to elucidate the fact that it is affecting the learners' context and therefore also their learning process. By discriminating some of the learners, the teachers are not giving them the opportunity to acquire the knowledge that they should. According to Vygotsky the learners bring their culture in to school and into the classrooms. But also the teachers do so, because they take part in creating the context.

8.1.2. Poverty

The learners' context is highly affected by social status and surrounding factors. As we mentioned earlier there is a lot of diversity in the learners' growth preconditions and background, playing a big part in the knowledge the learners bring into school. Apart from segregation many learners are struggling with poverty, which naturally affects the learners' context. As one of the teachers mentioned, the learners are not very concerned about global warming, their priority in life is to put food on the table, and that is the reason why the problem of global warming does not reach the learners in the way it does in more developed countries. The environmental knowledge is not spread among the population in South Africa. This is because there are more important things to care about, like where to stay, how to get food or water. A lot of people do not even have electricity.

We believe poor people tend to be more dependent on natural resources, and are therefore the first to suffer when these resources are depleted. They suffer more when water and air are polluted because they do not have the economic possibilities to change their living or their environment. In summary, we believe that poor people are more exposed to negative environmental changes and are least capable of coping when they occur. Despite our beliefs, only two out of ten interviewed learners (these two were from the same school) are linking global warming to poverty.

"*All over the global warming affects food which affects poverty which affects… It's like a chain reaction and unfortionally… we still, like, trying to rebuild ourselves. So it hits people quite hard here."*

Learner 1, Aberdale

"…I think the poverty and things will raise definitely. And like our government always been saying "…We going to build houses" and things like that, but things then never happen… like after apartheid happened and stuff... That was the government's slogan that was their thing. "We are going to provide it to our people". And it has never happened."

Learner 2, Aberdale

From our interviews we also got the information that many people in South Africa do not have the opportunity to prevent global warming in the way they would like and that it is not implemented in their society like it is in more developed countries. People have other huge social concerns to deal with first. A country like Sweden has the money to spread the environmental knowledge, South Africa does not.

"… So you see global warming doesn't reach them in the way the more developed countries are affected. We are affected but mostly we don't see it urban areas. …They are not so concern about the global warming, as I said before to you, I tell you, they know it but they struggle more to have food on the table to the families."

Teacher 4, Dale High

8.1.3. Safety

South Africa has a high rate of violence and crime, and we believe that one of the reasons for this is the widespread poverty. During our fieldwork we noticed that the learners are taking many safety precautions in their day-to-day life. We think this will affect the learners' context, making the segregation between races even more pronounced. We have also been thinking about how this safety awareness will affect the learning process. The learners get the knowledge in school about how they should live and how they could prevent environmental chances like global warming, but they do not have the opportunity to do so.

As we described, Dale High was placed in quite a rough area, with gunshot holes in the windows, barbwire on top of the walls and a guard watching the gate to the schoolyard. The safety thinking here was high and during a discussion with the teacher at Dale High he told us about the problems with gang formation among the learners. We think they do it to feel safe. Learners will join gangs to get protection. They will depend on the gang to stay alive and this will affect their school situation in a negative way.

In the section about current issues we described the safety thinking and the high crime rate. The kidnapping of young girls makes their families take precautions to ensure that their children get to school safely. This explains why they take the car even though they live nearby. In poor areas, like Comuxolo, only a few learners have the opportunity to go to school by car or by bus. These learners have a long walk to get to school and are exposed. They cannot protect themselves in the same way that learners in the more wealthy areas.

The majority of the learners in this study know that a car in motion have negative effects on the environment and the greenhouse effect. But in their context, the safety thinking exceeds their concern about preventing global warming.

8.1.4. Language

Säljö (2005) discusses the importance of using verbal tools in our everyday life. He also states that these tools are created by culture. Learners develop knowledge through communication.

As we earlier described, English is the common instructional language in South African schools. This is because of its status as a second language for many learners. Vygotsky argues that language makes it possible to have an ongoing social process among the learners. Barba (1998) agrees with Vygotsky that the verbal arena is the most important one for learning. Barba states that previous research has come to the conclusion that learners using their mother tongue in certain discussions get better self-esteem. It also improves the learners' attitude to learning, making it easier to acquire knowledge.

The interviewed teachers' awareness of language problems differs. The white teachers in our study are well aware that different mother tongues may cause problems for the learners' understanding. The learners have to struggle with understanding, not only the scientific phenomenon but also the language. The black and colored teachers reported that they have not noticed any misunderstandings due to language. This is probably a result of the fact that black and colored schools mostly have black and colored learners and that they often are educated in their (and also the teachers') mother tongue. The teachers in the white schools on the other hand have learners with different mother tongues that create language problems.

Just like Vygotsky´s and Barbra's discussion about the positive effects of being educated in a mother tongue, our study shows us that learners educated in another language than their mother tongue are overrepresented among the learners with misconceptions.

8.1.5. Education - supplies and the power of the teacher

Säljö (2005) writes that teaching, tutoring and supporting are the most important things to create the best opportunities for learning. We can clearly see how teachers and supplies are affecting the learning process. The range of teaching and the teachers' opinions of the learners at the different schools are enormous. In one of the schools the teacher assumes that the school is a dead end to many of the learners. With this point of view we find it hard to believe that the learners will get the support they need. This will surely affect their learning process.

According to the ongoing changes in the curriculum, many of the teachers are confused. They get new steering documents that do not comprehend guidelines in the same way as the syllabus from 1999. From what we could see many teachers were strictly teaching according to the textbook. This is something that we think limit the socio-cultural way of learning.

As we described in parts of our observations, the schools are using identical textbooks. These books are published in cooperation with the government. As we mentioned earlier the section on global warming and the greenhouse effect was minimal. We believe this reflects the importance, which the government attributes to global warming.

Before 1994 when apartheid was still a foundation in South African society there was also inequality between the teachers' education. If you were white you went to the university for five years in comparison to the black or colored that only received two years of education. The black and colored teachers we met were educated during the apartheid era and we think this can be important to their way of teaching and their knowledge. In present South Africa the teachers' education are equal regardless off socioeconomic status or race.

As we mentioned earlier, we agree with Barba that learners educated in their mother tongue achieve better results. Despite this, we have discovered the same misunderstandings and misconceptions in all four schools. This tells us that the learners' misconceptions are not only a result of language issues, but also a reflection of the teachers' knowledge, their way of educating and their culture.

8.2. Misconceptions

Boyes & Stanisstreet (1993) report that learners hold incorrect perceptions about Earth system relationships and about how human activities affect those systems. They also report that the misconceptions are similar in different education levels.

Misconceptions concerning carbon dioxide, the greenhouse effect and global warming are many and spread among the learners in our study. We clearly see that many learners do not know what the proportion of carbon dioxide is in the atmosphere. A lot of the learners state a higher rate than correct one and a number of learners believe that the atmosphere contains as much as 80-90% carbon dioxide. This misconception is probably the reason why many learners believe that we inhale more carbon dioxide than we exhale. An explanation to these answers can be the popularity of carbon dioxide. In all schools, both teachers and learners described global warming as a current issue that is discussed in media and in politics. Since the learners are often informed of the increasing rate of carbon dioxide, no wonder that they believe the rate is higher than it really is!

Another explanation to the incorrect perceptions may involve the teaching of environmental problems. The teacher speaks and teaches the learner about carbon dioxide, water vapor, global warming, the hole in the ozone layer etc, often at the same time (all the environmental problems are described in the same chapter in the textbook). The learners tend to mix up the information, transforming it to incorrect misconceptions.

Just like Gowda, Fox and Magelky (1997) report, another common misconception among our interviewed teachers and learners are that they personally could experience the rising temperatures. We think this is remarkable since the temperature has increased by approximately 1° Celsius during the last century. The misconception is probably a result of the ongoing discussion of global warming. Maybe the concept of global warming gets another meaning in their day-to-day life.

Boyes & Stanisstreet (1993) write that education should be based on the learner's level of knowledge and preconceptions and strive to fill known knowledge gaps, enhance understanding of relationships, and remediate misconceptions. We think that a contributing reason for everyday misconceptions could be that the learners are affected by external elements, for instance by the media. It is also clear that the teachers are important when it comes to explaining the student material for the learners so that they do not take everything too literally. The simplifications we can find in the literature are often too far stretched. In the different chapters, carbon dioxide and its role in nature are not shown clearly, which makes it hard to get a comprehension of the full orbit of carbon. We find that knowledge without context can be influenced more easily and there is a risk that learners fill in the gaps with their own explanations linked to their everyday life. Like Strömberg (2004) and Andersson (2001) we find that the education has to be based on the learner's idea of the world to create tension between everyday conceptions and scientific conceptions. We think that our answers would have been of considerably higher standard if the educating material had been correct and had its standpoint more in the learner's interests. As it says in the Swedish school curriculum, learners have to learn to distinguish between claims based on fact and claims that are evaluated standpoints, to be able to counteract everyday conceptions.

8.2.1. Carbon Dioxide - CO_2

The learners are showing good knowledge of the impact of carbon dioxide on the greenhouse effect (graph 4). On the other hand there are only a few learners who can explain the greenhouse effect as a phenomenon (graph 6). The Project: Theme state in the world from 1998 (Andersson, B. 2001, chapter 4) shows that only 5 % of high school learners are able to explain what the greenhouse effect is. The correspondent number in our study is approximately 20%. Most of these learners explain the greenhouse effect in a way that we think is OK, on the other hand we find that only 3% has a correct definition. The high rate of acceptable answers in our study may be a result of the current discussion of the phenomenon in society. It can also be a consequence of the fact that Andersson and we hold different opinions of what an acceptable answer is.

At first we found it remarkable that a high rate of learners in school 3 and 4 believe that carbon dioxide is formed when water is boiling. But an explanation to this result may be that the poor families of these schools actually use stoves heated by wood or coal. In that case the process of boiling water actually contributes to the forming of carbon dioxide.

Just like Gowda, Fox and Magelky (1997) and Andersson (2001) we are able to see that more than 60% of the learners believe that carbon dioxide in our atmosphere contributes to the depletion of the ozone layer (graph 4). This result may also explain the high rate of incorrect answers concerning carbon dioxide causing skin cancer (graph 4). We believe that the media and sometimes even learners' education create negative attitudes regarding carbon dioxide, making learners associate it with all kinds of environmental problems. This may also explain why some of the learners believe that carbon dioxide is toxic even in small amounts.
We can also see a lack of knowledge of the carbon cycle and of the interchange of carbon dioxide between the atmosphere and the ocean (graph 3). We find this remarkable because this is an essential part of the carbon cycle. An explanation to these knowledge gaps is probably the absence of this component in the textbook. We believe that these gaps make it harder for the learner to see the whole picture.

Most of the learners in all schools do not relate carbon dioxide to the section about production of electricity (graph 2). Considering the current shortage of electricity in the country, and the fact that most of the electricity is produced in coal power stations we find this result remarkable. Especially since the learners state that carbon dioxide is formed in coal power stations (graph 2). The ongoing load shedding is a huge problem in every economic and social group in the society. Everyone is affected and we think it is a really important problem they have to deal with. The problem is discussed both in the media, politics and in the society. This discussion is also related to the discussion of building a new nuclear power station in the country. Even though it is a current issue, it is not highly discussed in the schools. We believe that a socio cultural perspective on learning would elucidate this kind of current issue and use it in the school education.

8.2.2. Ozone layer

From the answers to our questionnaire we can determine that a lot of learners tend to mix up the greenhouse effect with the ozone layer:

"The ozone layer reduces the amount of heat that reaches the earth, all the gases are destroying it and to much heat is coming in…"

"The ozone layer deflects harmful rays from the sun but now that there is a hole in it, harm rays enter the earths atmosphere but cannot escape as the ozone deflects the rays back to earth."

"Carbon dioxide damages the ozone layer, there are holes in the ozone layer because of it. This allows more heat to reach to the earth, this heat traps gasses that are harmful in."

When describing the greenhouse effect almost all learners explain the phenomenon by using words such as layer or blanket against from which the rays from the sun are bouncing off. None of the learners are using the word absorbing. From the learners' and textbook explanations we can see where they get these misconceptions. The fact that they are using the term layer makes it easier to confuse it with the ozone layer. Another thing that contributes to the mix-up between the ozone layer and the greenhouse effect is that the learners are aware that pollution plays a part in both of them, making it more difficult to separate the two phenomena. Three of the teachers are aware of the difficulties in educating the learners about these specific topics. They are aware of the learner's way of mixing up the different environmental problems.

An explanation to the misconceptions regarding the greenhouse effect and the ozone depletion is probably an effect of lack of school supplies. The teachers' knowledge becomes more important and they use their own old textbooks in their education. The teachers were brought up and educated during a time when ozone depletion was a current issue. This may also explain why some learners believe that the atmosphere consist of ozone.

8.2.3. Greenhouse effect

As Gowda, Fox and Magelky (1997) describes, that learners from age 11 and up associate global climate changes with changes in weather. As well as Andersson (2001) we also see how the learners are explaining the effects of the increased greenhouse effect instead of the phenomenon of the greenhouse effect. *" It's getting warmer..."* The learners also tend to mix up the *natural* greenhouse effect, which is essential for life on earth, with the *increased* greenhouse effect, also known as global warming. An explanation to this may be that medias' approach can be unclear and sometimes even incorrect.

8.3. Summary

We believe that a general problem is that children are aware of a range of environmentally *friendly* and *unfriendly* actions, and cognizant of a range of environmental problems, but that they do not link particular causes with particular consequences. Rather, children appear to think in a general way that all environmentally *friendly* actions help all problems. We also believe that an understanding of major environmental problems is important because their solutions will require far-reaching changes in society, and that such education should begin early, before misconceptions become embedded in alternative conceptual frameworks and attitudes based on these frameworks become entrenched.

Every school we visited was a new experience. The context differs in many ways but based on our definition of the concept we could distinguish some things that are affecting the learning situation. In one way the schools work almost in the same organizational way with the staff, schedule and so on. On the other hand they are so different due to economic resources, the learners' backgrounds, history and living. Some learners live in wealth with never ending opportunities, other live in poor conditions, struggling to get by.

We cannot elucidate a specific factor causing the misconceptions among the learners. Instead, the scientific understanding is influenced by many different elements such as segregation, poverty, safety, language, schools supplies and the teachers' knowledge and their way of educating. We also believe that motivation and interest are playing a big part in the way learners acquire knowledge. These elements constitute the learners' day-to-day life and their context. Learners in South Africa have a complex context. No wonder that some of the learners have a lack of motivation and interest in global warming. A possible solution to catch the learners' interest is to involve the surroundings and the countries politics in the learning situation, making global warming involved in a socio-politic context.

9. Relevance for the teaching profession

During our time in South Africa we reflected upon how this study could guide us in our profession as teachers. The aim of this study is to explore how the learning process is affected by context. We have discussed the importance of the language and the learning situation in the classroom. A question we have asked ourselves is what kind of misconceptions the learners develop. We think this study will lead us to reach further in our understanding of this and that we in some ways will know how to deal with these misconceptions as well.

Our study is based on the socio-cultural perspective of learning. As we mentioned earlier, Lev Vygotsky is one of the most influential people when it comes to the socio-cultural perspective. A lot of research has been done after Vygotsky and all of it has referred to his research. We think it is important from our new point of view, after doing this study, to have this perspective in mind when reflecting on learning.

Kernell (2002) discusses many things in his book about the teaching profession. One thing he describes is a teaching situation from the 1950´s and what the classroom situation could look like. The teacher would be placed behind a desk on a stage in front of the learners and the pointer could be used to reprimand. An opposition between the teachers and the learners was established. The teachers were expected to be strict and authoritarian and the learners should behave with obedience and time-saver was a common item in the school situation. Some teachers would have the learners stand in line in the corridor before the lesson. The teacher was always in the central position during lessons and the learners could sometimes answer in chorus.

All these things that he describes as a common school situation 50 years ago look like the schools we visited in South Africa. Kernell describes the behaviorist perspective on learning, according to which learning is based on positive and negative stimuli and response. If the learners were listening carefully and were concentrated they would learn what the teachers offered them. The development in connection with the learning process was not as relevant as it is in the education today (Kernell, 2002). According to Silwa Claesson we can see this as an empiristic perspective of learning. Empirists see the learners as empty bins that can be filled with knowledge. The learners absorb the information passively and the learning environment is based on the teacher, books, classroom and experiments. To know something is to remember and repeat it (Claesson, 2002).

This empiristic perspective is in opposition to the socio-cultural view on learning where the context, conversation, culture and language are the most important things in the learning situation. To acquire knowledge is to relate and to use it in new situations. The reflection on the process of learning is something Dyste discusses. How people interact has been the central part in this research since Vygotsky. Dyste writes that Cole and Wertsch have developed these thoughts and they introduced a new concept in reference to the learning process. We need tools or instruments that can support or help us to learn. These tools or instruments are in this perspective described as experiences and knowledge from earlier generations. The combination of humans and these tools create new opportunities to understand and acquire knowledge. The source to learning is the social factors, which are based on historical and cultural coherence and relations and interactions between people. The most important tool in the process is language (Dyste 2003).

Roger Säljö is a Swedish researcher in the socio-cultural perspective on learning at the University of Gothenburg. His research has been dealing with the importance of language in learning and thinking. The humans among all species are equipped to develop and use physical and verbal tools.

"The languages is concurrently a collectively, interactive and individually sociocultural tool. That is why it can be used as a link between culture, interaction and individual thoughts."
Säljö 2000, s.87, our translation

Due to the socio-cultural perspective the communicative process is a precondition to the human way of learning and progressing. By listening, conversing and interacting with each other we acquire knowledge and skills and get to know the culture in which we are situated. Language is not only a precondition for learning; it is the foundation of learning and thinking. Communication is even a link between culture and human thoughts (Dyste 2003).

As we can see communication is a central factor in learning. In a school situation, which means dialogue, discussing in groups or communicating through media. Another prominent figure in the sociocultural perspective is Dewey. He has been associated with the words *learning by doing*. He emphasizes the importance of the learner's right to actively investigating and acting (Claesson 2002).

The learners discuss their thoughts and they can see that there are many ways to look at a specific phenomenon. The teacher's role is to tutor and be there with the scientific and correct answer. The learners then reflect and acquire knowledge due to context and earlier experiences (Carlgren & Marton, 2002).

One of the most important things we as professional teachers need to be able to do is to understand others perspectives on different phenomena. This is why language is so important in the process of learning. To explain, discuss and understand others' point of view give the learners the opportunity to learn. It even gives us as teachers the opportunity to make the learning environment as pleasurable as possible to the learners. (Kernell, 2002) The process of learning and the learners' development are interwoven and dependent. To develop, we need to get into a situation where we can learn (Dyste, 2003).

In one part of the discussion we brought up some points regarding the teachers' lack of ability of connecting current issues, like load shedding, from the society into the education situation. We think this is a problem teachers have to deal with to give learners the best chance to acquire new understanding and knowledge. Teachers also have to give learners a communicative space, but also the opportunity to establish new knowledge with their experiences and social surroundings. This is a way for them to see the relevance of the knowledge, but also to give the learners the possibility to reflect. In this way they have tools taken from their own environment and history that will work as instruments so they can deal with the information the teacher conveys.

We are discussing the misconceptions from a sociocultural point of view and we think it is important to challenge these misconceptions. This is the learner's idea of the world. We can only agree with Strömberg and Andersson (2001) that these misconceptions are the starting point for the process of learning. We as teachers give the learners the opportunity to use the tools, discuss, see other perspectives and develop knowledge. To map out these misconceptions when you first meet a new group of students would be a truly productive way

of initiating a learning process where the teachers and students could start by discussing these concrete misconceptions.

To come back to the three concepts that we brought up in the introduction; potential, opportunity and precondition, we as teachers will say that these concepts really build up the foundation in the process of learning. This process is complex but it is one of the most important things we as teachers need to understand and always keep in mind, in all school-, learning-, educating- and planning- situations. This is because we want to give our learners the best opportunity to learn and develop their scientific knowledge. We really want to say that we will have a better understanding of this after having done study.

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11. Appendix

11.1. Questionnairie on Global warming.

Part I

1. Gender: Male ☐ Female ☐

2. Age:_____

3. Mother tongue? _____

4. Country of birth? _____

5. Who are you living with?_____

6. How many brothers and sisters do you have?_____

7. How many hours per day do you spend watching telvision?

0-1 h ☐ 2-3 h ☐ 4-5h ☐ more than 5 h ☐

8: How do you mostly keep up to date with the latest news? (Please select one alternative)

TV ☐ Newspaper ☐ Internet ☐ Friends ☐

9. What is the distance between your home and your school?_____

10. How do you go school? (You can select more than one alternative)

By car ☐ By Bus ☐

Bicycle ☐ Walking ☐

Train ☐

Other:_____

11. Do you recycle your refuse? Yes ☐ No ☐

Part II

1. A. Which are the most common gases in the atmosphere that you know of?

B. Of the gases that you mentioned above, what percentage of each one do you think is in the atmosphere?

0 100 %

2. How is carbon dioxide formed?
Answer either Yes/No to whether carbon dioxide is formed during each of the following cases.

A. A car in motion	Yes	No
B. Wood is burning	Yes	No
C. Water is boiling	Yes	No
D. Oil is burning	Yes	No
E. Oil spill in the sea	Yes	No
F. A man is walking	Yes	No
G. A man is sleeping	Yes	No
H. A power station using coal to generate elctricity	Yes	No
I. A nuclear power station generating electricity	Yes	No
J. A wind power station generating electricity	Yes	No

3. How can carbon dioxide be removed from the atmosphere?

It can be absorbed by the ocean	Yes	No
It can be absorbed by green plants	Yes	No
It can be removed when you are burning wood	Yes	No
It can be removed when you use a catalytic converter in your car.	Yes	No
It can be absorbed by the ozone layer	Yes	No

4. Examine the following statements relative to carbon dioxide and say whether they are either True or False.

- Results in destruction of the ozone layer	True	False
- We exhale more than we inhale	True	False
- Is toxic for humans in small amounts	True	False
- Leads to the acidification of land and lakes	True	False
- Results in the greenhouse effect	True	False
- It is a gas at room temperature	True	False
- Increases the risk of skin cancer	True	False
- Leads to to parched fields	True	False

5. The weight of a growing tree increases by 100 kilograms. What is responsable for this increase in weight?

A. Soil + water
B. Water + air
C. Water + nutrition
D. Soil + nutrition

6. Is carbon dioxide essential in nature? Yes ☐ No ☐

7. I which sections coverd by your teacher in school was carbon dioxide and its role in nature discussed?

- Combustion
- Photosynthesis
- Greenhouse effect
- Global warming
- Producing electricity
- Burning of fossil fuels
- Respiration

8. How would you explain the greenhouse effect to a friend?

_____
_____
_____
_____
_____
_____
_____
_____
_____

Thank you for answering this questionnaire!

Lisa Andreasson & Therese Noborg

11.2. Interview Questions

11.2.1. Interview Learner

Names:
Ages:

1. Do you get any education about the greenhouse effect and global warming in school?
- In what subjects?
- Which grades?

2. How would you explain the greenhouse effect and the global warming?

3. What do you think is the main reason for global warming?

4. Do you do anything that leads to the increased greenhouse effect?
- In such a case, how?

5. What can you do to prevent the global warming?
- Do you have the opportunity to do this?
- Why / why not?

6. Do you think other people, in your neighbourhood, are aware of how their actions in everyday life can result in the global warming?

- Do you think they know how to prevent global warming?

No	→	Why not?
Yes	→	Are they doing this preventing thins?

No	→	Why not?
Yes	→	Example?

7. Do you see any changes in the enviornment here in South Africa that is a result of the global warming?
- And how does this affect you?

8. Is global warming a current issue in South Africa?
- In what context?
- Have you heard about it somewhere else besides school?

9. How do you think the global warming will affect South Africa in the future?
- How will it affect you in the future?

11.2.2. Interview Teacher

Name:
Age:
Mother tongue:
Do you live close to this school?

How many years have you been working as a teacher?
- Different schools?
- What kind of schools?

1. How do you explain the greenhouse effect and global warming to your pupils?

2. In which school subject is the greenhouse effect and global warming discussed?
- What grades?

3. What kind of school supplies do you use when you teach greenhouse effect and global warming?
- What kind of school supplies do the learners have?

4. Are there any difficulties to teach the pupils about this?

5. What do you think are the most important things the learners need to know about the greenhouse effect and global warming?

6. Have you noticed any misunderstandings due to greenhouse effect and global warming?

7. During your time as a teacher, have you seen any changes in the pupil's knowledge about greenhouse effect and global warming?

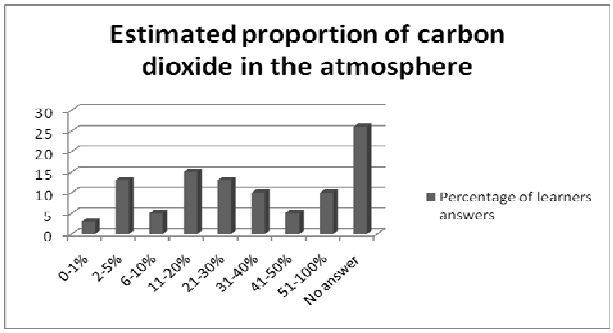
8. Is global warming an issue that are discussed in media and politics here in South Africa?
- In what context?

9. Do you see any changes in the enviornment here in South Africa that is a result of the global warming?

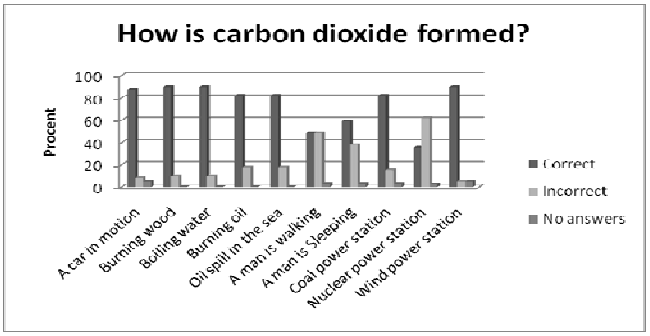
10. How do you think the global warming will affect South Africa in the future?

11.3. Graphs from results

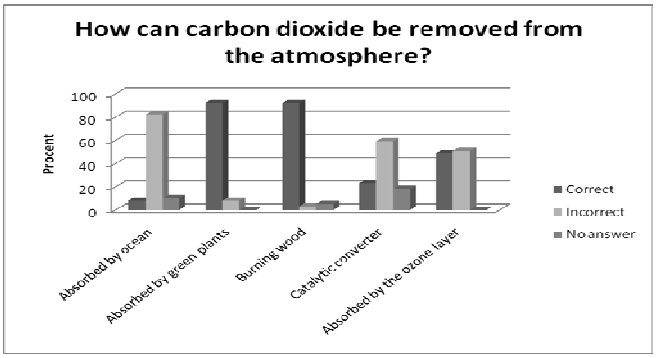
11.3.1. School 1 - Aberdale



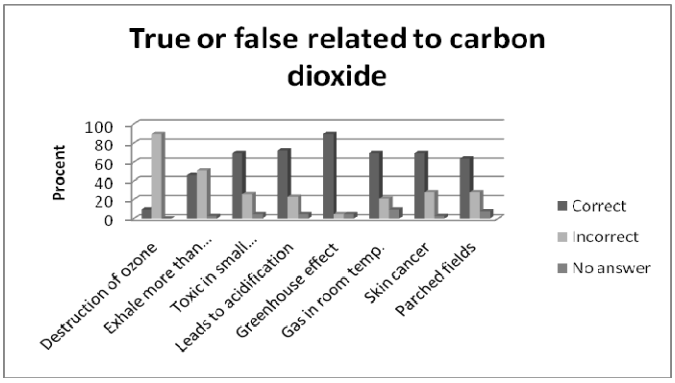
Graph 7: Learners misconceptions concerning the proportion of carbon dioxide in the atmosphere



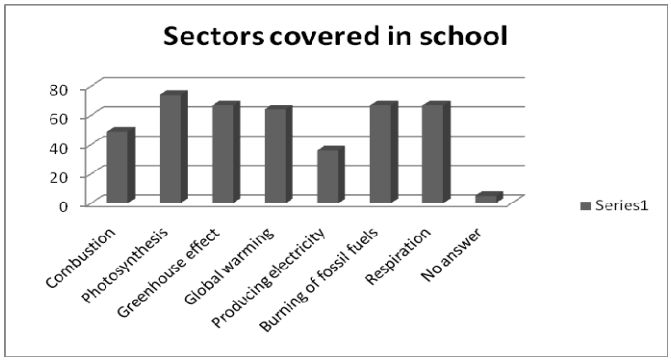
Graph 8: How is carbon dioxide formed?



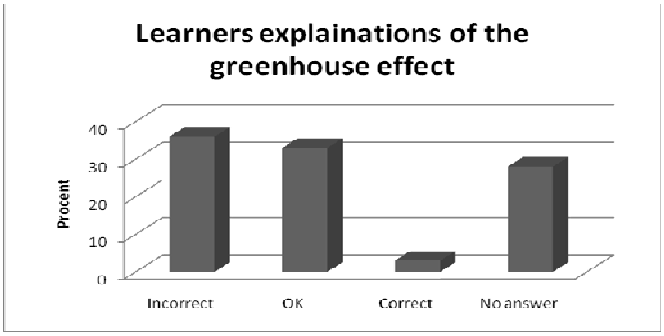
Graph 9: How can carbon dioxide be removed from the atmosphere?



Graph 10: True or false about carbon dioxide.

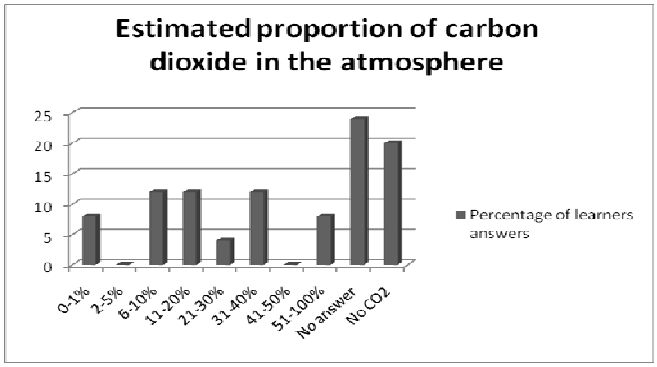


Graph 11: In which sections covered by your teacher in school was carbon dioxide and its role in nature discussed?

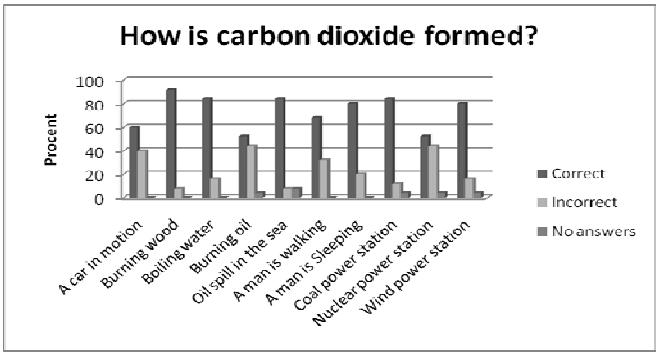


Graph 12: How would you explain the greenhouse effect to a friend?

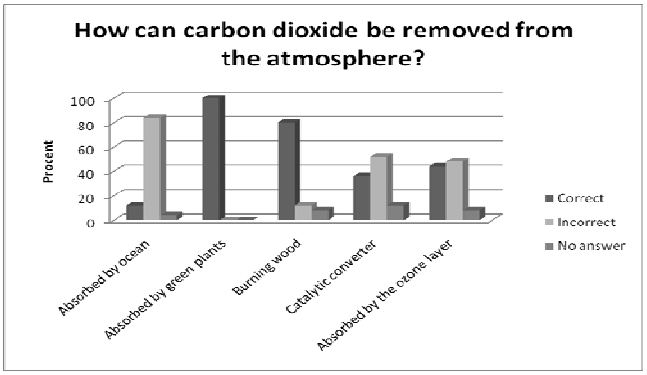
11.3.2. School 2 - Belveder



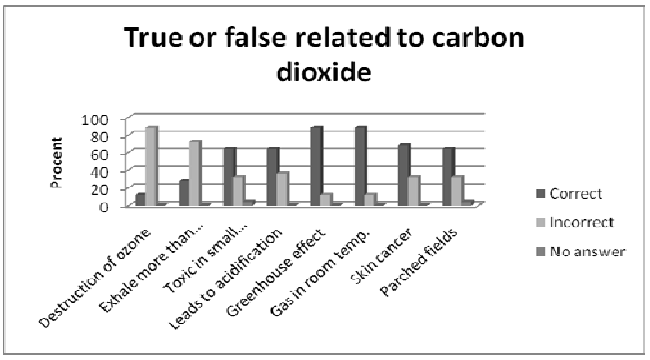
Graph 13: Learners misconceptions concerning the proportion of carbon dioxide in the atmosphere



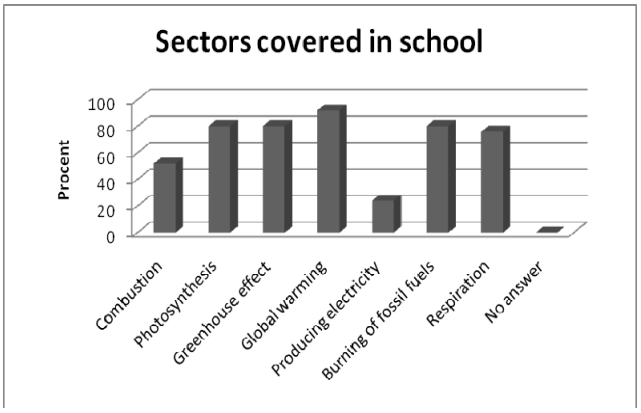
Graph 14: How is carbon dioxide formed?



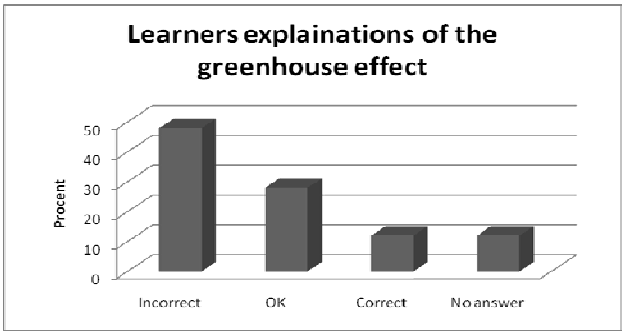
Graph 15: How can carbon dioxide be removed from the atmosphere?



Graph 16: True or false about carbon dioxide.

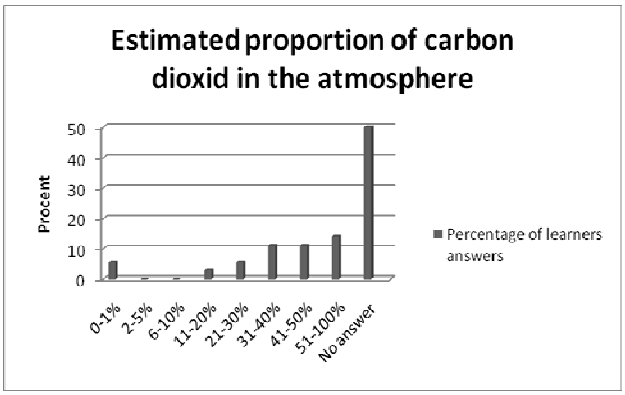


Graph 17: In which sections covered by your teacher in school were carbon dioxide and its role in nature discussed?

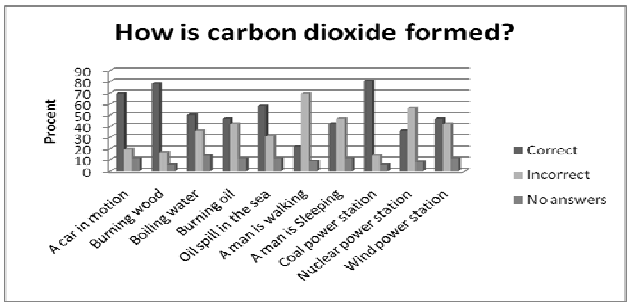


Graph 18: How would you explain the greenhouse effect to a friend?

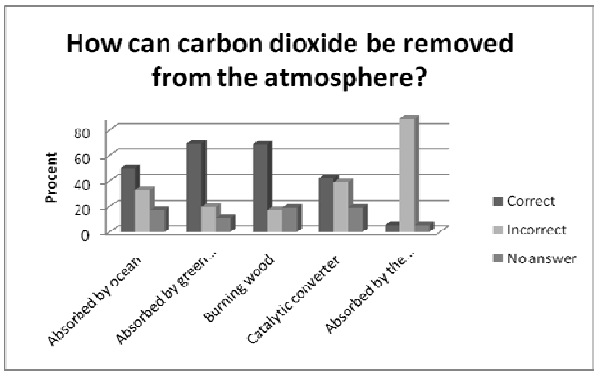
11.3.3. School 3 - Comuxolo



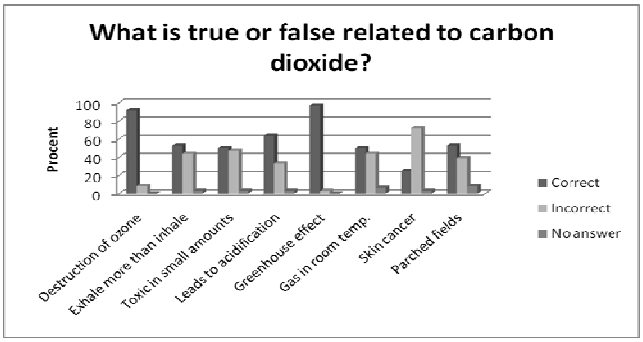
Graph 19: Learners misconceptions concerning the proportion of carbon dioxide in the atmosphere



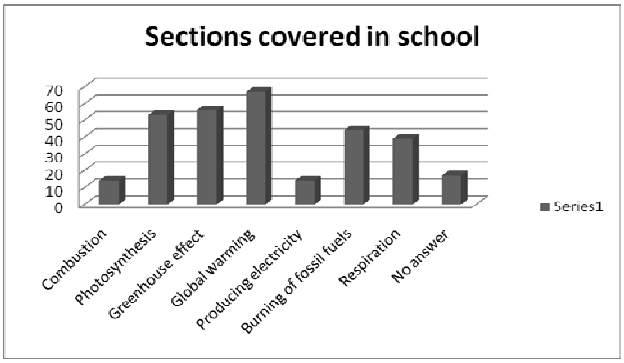
Graph 20: How is carbon dioxide formed?



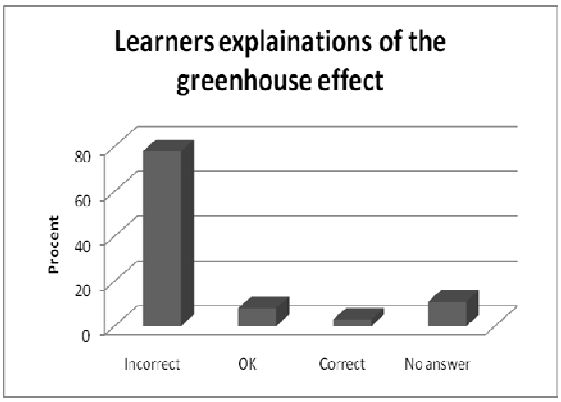
Graph 21: How can carbon dioxide be removed from the atmosphere?



Graph 22: True or false about carbon dioxide.

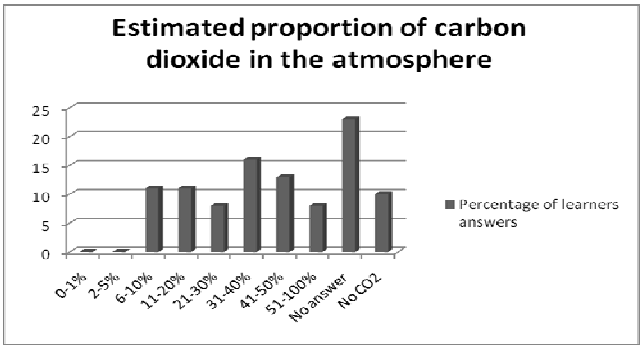


Graph 23: In which sections covered by your teacher in school was carbon dioxide and its role in nature discussed?

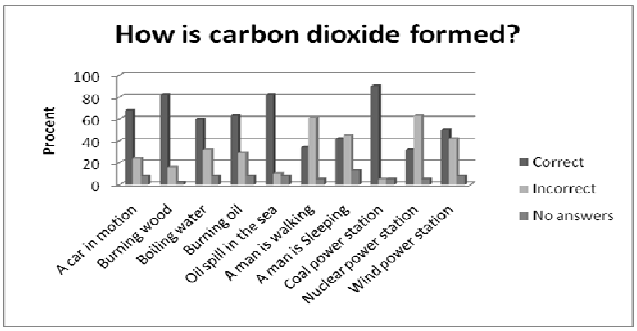


Graph 24: How would you explain the greenhouse effect to a friend?

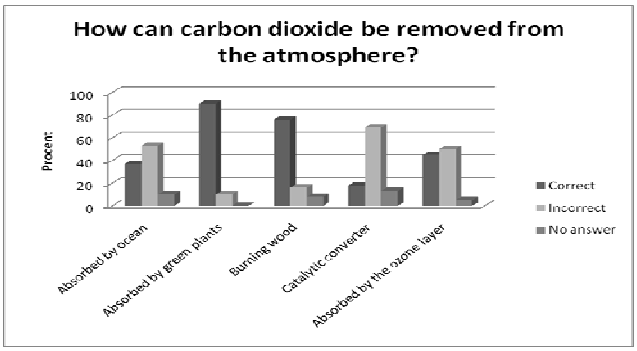
11.3.4. School 4 – Dale High



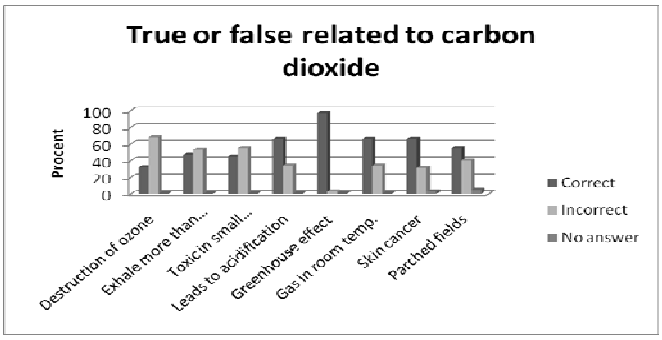
Graph 25: Learners misconceptions concerning the proportion of carbon dioxide in the atmosphere.



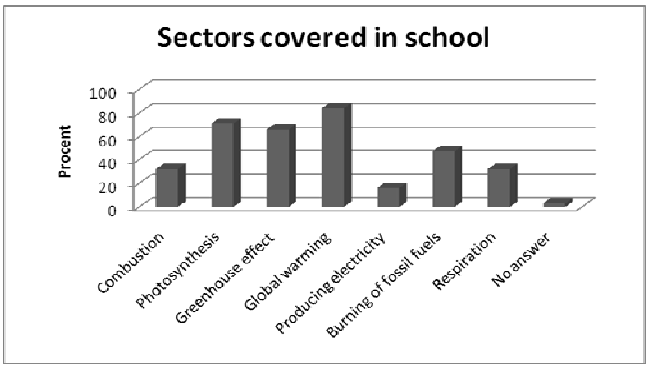
Graph 26: How is carbon dioxide formed?



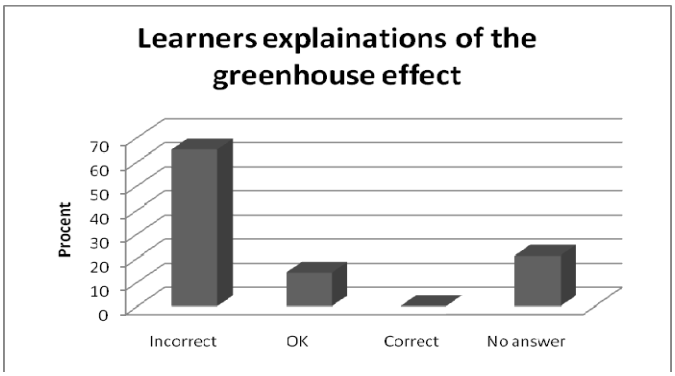
Graph 27: How can carbon dioxide be removed from the atmosphere?



Graph 28: True or false about carbon dioxide.



Graph 29: In which sections covered by your teacher in school was carbon dioxide and its role in nature discussed?



Graph 30: How would you explain the greenhouse effect to a friend?

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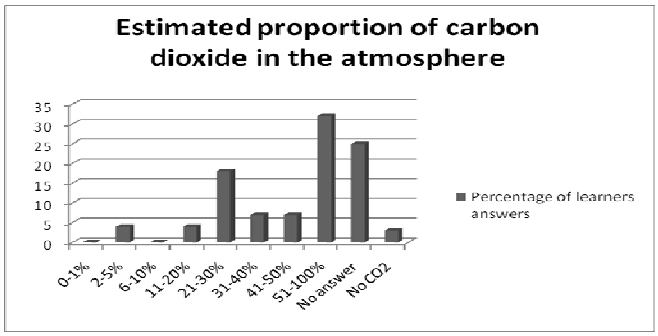
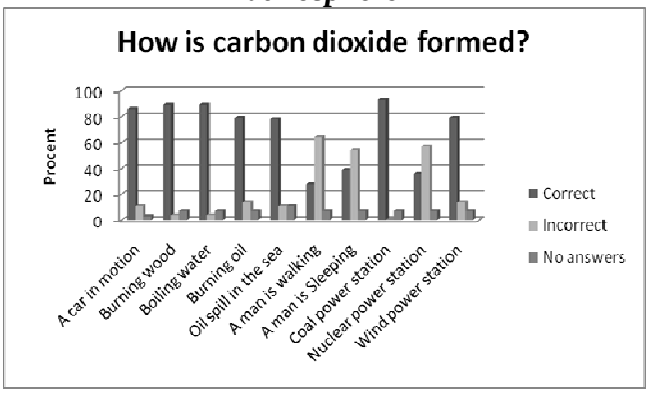
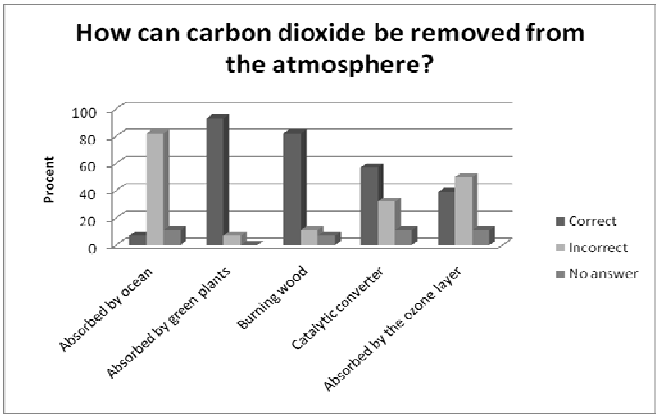


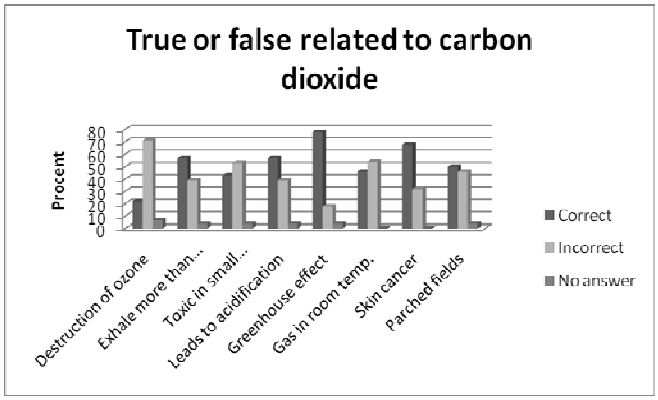
Graph 31: Learners misconceptions concerning the proportion of carbon dioxide in the atmosphere



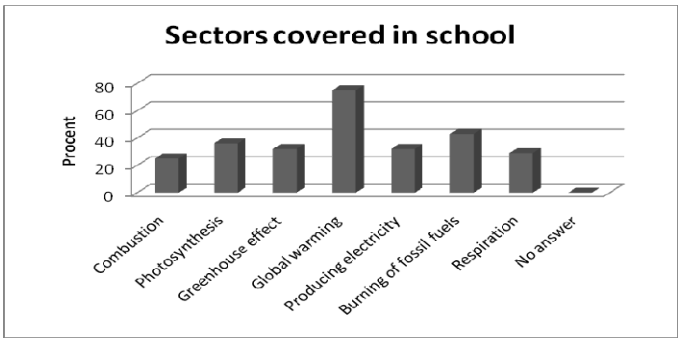
Graph 32: How is carbon dioxide formed?



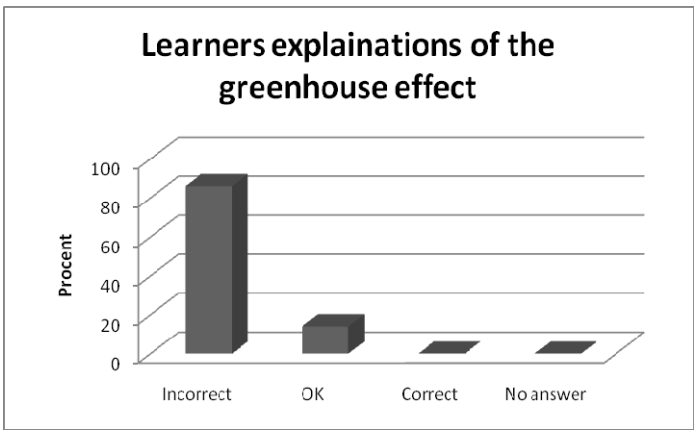
Graph 33: How can carbon dioxide be removed from the atmosphere?



Graph 34: True or false about carbon dioxide.



Graph 35: In which sections covered by your teacher in school was carbon dioxide and its role in nature discussed?



Graph 36: How would you explain the greenhouse effect to a friend?